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PLANE STRAIN FRACTURE TOUGHNESS (KIC) DATA HANDBOOK
FOR METALS

ARMY MATERIALS AND MECHANICS RESEARCH CENTER

DECEMBER 1973

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ABSTRACT

A compilation of plane strain K_{IC} data is presented for metals manufactured in the USA and Europe, including 50 steels, 21 titanium alloys, 38 aluminum alloys, and one beryllium material. The data corresponds to static loading in neutral laboratory environment. The effect of temperature is included in the tables along with the direction of testing, the form and size of the material, its composition and heat treatment, and the specimen type and size. (Author)

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INTRODUCTION

The plane strain fracture toughness values presented in this compilation are expressed in terms of linear elastic fracture mechanics. These K_{IC} values have been obtained by the ASTM E399-72 "Standard Method of Test for Plane Strain Fracture Toughness Testing of Metallic Materials" or a similar method. This data compilation includes materials manufactured in the USA and Europe. The following factors are involved in the selection and interpretation of the K_{IC} values.

Testing Conditions

The material values shown correspond to quasi-static loading of approximately one to three minutes duration. The environment is a neutral laboratory environment in which no aggressive chemicals or extreme of humidity are intentionally introduced.

Specimen Types

K_{IC} values shown have been obtained from ASTM recommended bend and compact tensile specimens and from a variety of other specimens: four-point bend, double cantilever beam, wedge opening loading, side edge notched, center cracked specimens and a few double edge cracked and notched round specimens. Surface cracked specimen data is not included in the appendix since, although this configuration is extremely important in applications, criteria for validity of K_{IC} measurements of surface cracked specimens have not been established.

Criteria for Validity of Typical K_{IC} Values

The ASTM E399-72 requirements are taken as the general guide for validity. However, since complete details of factors cited by ASTM are usually not available, personal judgment must be exercised. For example, although all data listed pertain to fatigue-cracked specimens, the range of imposed K_I during fatiguing is usually not reported. In addition, the crack front curvature and the orientation of the crack plane with respect to the loading axis are also unknown. Other typical unknowns are the critical crack length, the details of selection of the critical load value, the appearance of the fracture surfaces, the details of fixture design to minimize friction and the linearity of the displacement gage. Therefore, it is often necessary to assume that in general the test measurements have been carried out according to good practice. In terms of specific criteria for inclusion in this tabulation the ASTM requirement of thickness greater than $2.5 (K_{IC}/\sigma_{YS})^2$, was applied. Virtually all of the data satisfied this requirement. Although it would be desirable to require that crack length exceed $2.5 (K_{IC}/\sigma_{YS})^2$, this criterion was not rigidly imposed. The minimum reported crack length for data presented in this appendix is $1.25 (K_{IC}/\sigma_{YS})^2$.

Accuracy of K_{IC} Values

In general the K_{IC} values shown are averages of several tests. The range of typical data may be interpreted to be the average shown $\pm 10\%$. In cases where the range of toughness values was large, either the entire range is shown or the extremely high values were excluded before computing the average. It should be recognized that these accuracy limits refer only to the specific results obtained and may not be appropriate in general for material of the same nominal composition, form, and size which is processed and tested elsewhere.

Parameters Influencing K_{IC}

Where available, the influence, whether significant or negligible, of material form and thickness, composition, heat treatment, testing temperature and material anisotropy and yield strength upon K_{IC} is shown by the series of data entered in the tables. In most cases where a particular heat treatment produces both the highest yield strength and toughness, data for other heat treatments are omitted. It is important to note that for some materials, data from the combination of composition and processing which leads to the highest toughness is not included in this compilation. In those instances it is not possible to obtain valid K_{IC} measurements for the particular material thickness of interest. There are additional parameters which may also influence K_{IC} values which are not shown in these tables since they are rather infrequently reported. These include melting practice, heat treating practice such as the size of quenching bath relative to the material size, and the amount of material straining during forging.

DEFINITION OF SYMBOLS AND UNITS

Units, Symbols and Nomenclature

Data is presented in the customary units used in the United States with accompanying International System Units (SI) in parentheses. The definition of units and symbols for specimen orientation and type are given preceding the tabulations.

a) Composition and Heat Treatment Codes

Code Form: Letter, Number

Letter - Identifies Composition

Number - Identifies Heat Treatment

Detailed descriptions of composition and heat treatment are at the bottom of each table. The compositional values are measured values in terms of percentage by weight, except when designated ppm (parts per million).

When only specified composition is available, the nominal specified levels are followed by the letter "N" and the maximum levels of other elements are followed by "F".

b) Orientation of Specimens

Code: First letter: Direction of Loading

Second letter: Direction of Crack Propagation

L: Direction Parallel to Primary Grain Flow Direction of Plate, Forging or Extrusion

T: Direction Parallel to Largest Dimension in Plane Transverse to L Direction

S: Direction Parallel to Smallest Dimension in Plane Transverse to L Direction

ST4: Direction 45° Between Directions of Largest and Smallest Dimension in Plane Transverse to L Direction

R: Radial Direction

C: Circumferential Direction

If a direction is ambiguous in terms of two of the above definitions, then both directions are shown.

c) Specimen Identification

Bend: 3-point Bend Specimen

Bend (4 pt): 4-point Bend Specimen

CT: ASTM Compact Tensile Specimen

WJL: Similar to CT, but with different dimensions

CC: Remotely Loaded Flat Tensile Specimen with Center Notch

DEC: Remotely Loaded Flat Tensile Specimen with Double Edge Cracks

SEN: Remotely Loaded Flat Tensile Specimen with a Single Edge Crack

NR: Round Tensile Specimen, Circumferentially Notched

DCB: Double Cantilever Beam Specimen

d) Units

Temperature: F - Degrees Fahrenheit

K - Degrees Kelvin

Stress: KSI - Kips per Square Inch

MN/m² - Mega Newtons per Square Meter

Stress Intensity: KSI $\sqrt{\text{in}}$ - Kips per Square Inch Times Square Root Inches

MN m^{3/2} - Mega Newtons times (Meters)^{3/2}

Length: in, mm - Inches, Millimeters

ft, m - Feet, Meters

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Steel, Low Alloy: AISI 4330M, EN30B

Table 1

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} KSI/ \sqrt{in} ($\frac{N}{mm^{3/2}}$)	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen				Ref.			
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)				
AISI 4330M Cylindrical Forging 15.5 in. (394 mm) OD 6.5 in. (16.5 mm) ID 35 ft (10.7 m) Long	A,1	C-R	70(294)	181(1248)	120(131)	1.10(27.9)	NOL 1.0	(25.4)	2.75(69.8)	---	1			
	A,1	C-R	-20(244)	---	120(131)	---	NOL 1.0	(25.4)	2.75(69.8)	---				
	A,2	C-R	70(294)	157(1100)	120(131)	1.47(37.3)	NOL 1.0	(25.4)	2.75(69.8)	---				
	A,2	C-R	-60(222)	---	45(49)	---	NOL 1.0	(25.4)	2.75(69.8)	---				
	B,3	L-T	70(294)	210(1448)	55(60)	0.17(4.3)	NR D=	0.353(19.9)	---	---	2			
		L-T	-100(200)	---	40(44)	---	NR D=	0.353(19.9)	---	---				
	C,4	L-T	70(294)	198(1365)	84(92)	0.45(11.4)	Bend0.48 (12.2)1.5	(38.1)0.3	(7.6)	---	3			
		L-T	-65(219)	---	64(70)	---	Bend0.48 (12.2)1.5	(38.1)0.3	(7.6)	---				
		L-ST	70(294)	198(1365)	68(75)	0.29(7.5)	Bend0.313(7.8)	0.5	(12.7)0.25	(6.4)	5			
		L-ST	70(294)	207(1427)	65(72)	0.247(6.3)	Bend0.315(8.0)	0.5	(12.7)0.26	(6.6)				
EN30B Bar: 0.56 in. (14.2 mm) Square	D,6	L-ST	70(294)	216(1489)	56(62)	0.168(4.3)	Bend0.315(8.0)	0.5	(12.7)0.21	(5.3)				
	D,7	L-ST	70(294)	232(1600)	74(81)	0.254(6.5)	Bend0.315(8.0)	0.5	(12.7)0.25	(6.4)				
	D,8	L-ST	70(294)	243(1710)	68(75)	0.188(4.7)	Bend0.315(8.0)	0.5	(12.7)0.22	(5.6)				
	D,9	L-ST	70(294)	---	---	---	---	---	---	---				
	COMPOSITION													
					C	Si	Mn	S	P	Mo	Ni	Cu	V	
					A	0.34	0.22	0.50	0.011	0.012	0.58	3.08	1.15	0.13
					B	0.31	1.59	---	---	---	0.40	1.80	2.04	0.07
					C	0.28	0.38	0.80	0.007	0.009	0.44	1.84	0.90	0.04
				D	0.52	0.20	0.49	0.009	0.012	0.24	4.09	1.22	---	
HEAT TREATMENT														
1. 1550F (839K), 4 Hr. Quench in Lead Bath 931F (500K); Ausformed, 70% Reduction, Air Cooled; Temper 750F (405K), 1 Hr.														
2. 1550F (839K), 4 Hr. Quench in Lead Bath 931F (500K); Ausformed, 70% Reduction, Air Cooled; Temper 750F (405K), 1 Hr.														
3. 1700F (927K), 1 Hr, Oil Quench; Temper 600F (316K), 1 Hr, Air Cool														
4. 1750F (955K), 1 Hr, Oil Quench; Temper 500F (260K), 3 Hr, Air Cool														
5. Hot Rolled, Air Cooled; 1525F (835K), 1 Hr, Oil Quench; Temper 391F (200K), 1 Hr														
6. Heated at 54F (30K)/sec to Ac3 Temp, Quench; Temper 661F (350K), 1 Hr														
7. Heated at 54F (30K)/sec to Ac3 Temp, Quench; Temper 391F (200K), 1 Hr														
8. 1796F (975K), 1 Hr. Quench in Lead Bath 931F (500K); Ausformed, 70% Reduction, Air Cooled; Temper 750F (405K), 1 Hr.														
9. 1796F (975K), 1 Hr, Quench in Lead Bath 931F (500K); Ausformed, 70% Reduction, Air Cooled; Temper 391F (200K), 1 Hr														

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COMPOSITION

	C	Si	Mn	S	P	Mo	Ni	Cu	V
A	0.34	0.22	0.50	0.011	0.012	0.58	3.08	1.15	0.13
B	0.31	1.59	---	---	---	0.40	1.80	2.04	0.07
C	0.28	0.36	0.80	0.007	0.009	0.44	1.84	0.90	0.09
D	0.32	0.20	0.49	0.009	0.012	0.24	4.09	1.22	---

Steel Low Alloy: 1. 2D16, EN40C

Table 2

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 (K _{IC} ² / σ _{ys}) in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	
35NCD16										
Bar: Vac. Arc. Remelt	A, 1	L-R	70(294)	191(1317)	72(79)	0.355 (9.0)	(a)	---	---	67
	A, 2	L-R	70(294)	202(1393)	72(79)	0.318 (8.1)	(a)	---	---	
	A, 3	L-R	70(294)	211(1455)	67(74)	0.252 (6.4)	(a)	---	---	
	C, -	T-S	70(294)	208(1344)	74(81)	0.316 (8.04)	Bend 0.5 (12.7)	1.0 (25.4)	---	60
	C, -	T-S	70(294)	216(1489)	72(79)	0.278 (7.1)	Bend 0.5 (12.7)	1.0 (25.4)	---	
	C, -	T-S	20(294)	222(1521)	71(78)	0.256 (6.5)	Bend 0.5 (12.7)	1.0 (25.9)	---	
EN40C										
Bar: 0.56 in (14.2 mm) sq.	B, 4	L-R	70(294)	218(1503)	60(66)	0.189 (4.8)	Bend 0.313(8)	0.5 (12.7)	0.23(5.8)	5
	B, 5	L-R	70(294)	239(1648)	59(65)	0.152 (3.9)	Bend 0.313(8)	0.5 (12.7)	0.15(3.8)	
	, 6	L-R	70(294)	260(1793)	55(61)	6.112 (2.8)	Bend 0.313(8)	0.5 (12.7)	0.21(5.3)	
	B, 7	L-R	70(294)	317(2186)	44(48)	0.048 (1.2)	Bend 0.313(8)	0.5 (12.7)	0.12(3.0)	
(a) Specimen in accordance with ASTM Recommendations.										
COMPOSITION										
	C	Si	Mn	Ni	Cr	Mo	V	S	P	Al
A	0.35	0.27	0.33	3.99	1.69	0.44	0.05	0.009	0.009	0.026
B	0.37	0.26	0.54	0.13	2.98	0.90	0.23	0.013	0.015	---
C	0.35N	0.4M	0.35N	4.0N	1.75N	0.45N	-	0.03M	0.03M	---
HEAT TREATMENT										
1. 1705 (1203K), Air Cool; 1606F (1148K), Air Cool; -95F(203K); Temper 751F (673K), 2 Hr										
2. 1705 (1203K), Air Cool; 1606F (1148K), Air Cool; -95F (203K); Temper 661F (623K), 2 Hr										
3. 1705 (1203K), Air Cool; 1606F (1148K), Air Cool; -95F (203K); Temper 42°F (493K), 2 Hr										
4. 1650F (1172K), Oil Quench; Temper 571F (573K), 1 Hr										
5. Heated at 54F (30K)/sec to A _{c3} Temp, Immediate Quench to 70F (294K); Temper 571F (570K), 1 Hr										
6. 1796F (1253K), 1 Hr, Quench in Lead Bath 1021F (823K); Ausformed 70% Reduction, Air Cooled; Temper 391F (473K), 1 Hr										
7. 1796F (1253K), 1 Hr, Quench in Lead Bath 1021F (823K); Ausformed 70% Reduction, Air Cooled; Temper 571F (573K), 1 Hr										

Table 3

Table 3

11

Form	C'po- sition, Heat Treat- ment	Test Orienta- tion	Temp of F _c (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{1/2})	2.5 (K _{IC} σ _{ys}) ² in (mm)	Specimen			Ref.	
							Thickness in (mm)	Width in (mm)	Crack Length in (mm)		
Plate: 0.0085 in (2.2 mm) Thick	A,1	L-T	75(297)	243(1675)	40(44)	0.068(1.7)	CC	0.085(2.2)	1.75(4.44)	0.7 (17.8)	54
		L-T	-103(200)	257(1760)	35(38)	0.046(1.2)	CC	0.085(2.2)	1.75(4.44)	0.7 (17.8)	
	A,2	L-T	75(297)	231(1590)	35(38)	0.057(1.4)	CC	0.065(2.2)	1.75(4.44)	0.7 (17.8)	
		L-T	-100(200)	240(1555)	31(34)	0.042(1.1)	CC	0.085(2.2)	1.75(4.44)	0.7 (17.8)	
Plate: 0.5 in (12.7 mm) Thick	B,3	L-T	200(367)	202(1393)	55(60)	0.195(4.7)	Bend	0.5 (12.7)	1.3 (25.5)	0.23(5.8)	7
		L-T	75(297)	212(1462)	34(37)	0.064(1.6)	Bend	0.5 (12.7)	1.0 (25.5)	0.28(7.1)	
		T-L	75(297)	204(1407)	32(35)	0.061(1.5)	Bend	0.5 (12.7)	1.0 (25.5)	0.25(6.6)	
		L-T	-50(238)	216(1489)	23(25)	0.028(0.7)	Bend	0.5 (12.7)	1.0 (25.5)	0.26(6.6)	
		L-T	-100(200)	228(1572)	21(23)	0.021(0.5)	Bend	0.5 (12.7)	1.0 (25.5)	0.23(5.8)	
Bar: 1 in (25.4 mm) Thick	C,4	L-T	200(367)	198(1365)	81(89)	0.418(10.6)	Bend	1.03 (26.2)	0.94(23.8)	0.24(6.1)	
		L-T	-50(238)	210(1448)	25(28)	0.035(0.9)	Bend	0.75 (19.1)	0.75(19.1)	0.13(3.3)	
		L-T	-100(200)	220(1517)	23(25)	0.027(0.7)	Bend	1.0 (25.4)	1.0 (25.4)	0.28(7.0)	
Forging: 3 in (76.1 mm) Thick	D,5	T-L	70(294)	189(1303)	45(49)	0.142(3.6)	Bend 4 pt	0.18 (12.2)	1.5 (38.1)	0.3 (7.6)	3
		T-L	-65(219)	---	35(38)	---	Bend 4 pt	0.48 (12.2)	1.5 (38.1)	0.3 (7.6)	
Forging: 8 in (203 mm) Square	E,1	T-L	70(294)	225(1551)	38(41)	0.071(1.8)	Bend	0.75 (19.1)	0.75(19.1)	0.15(3.8)	12
	E,2	T-L	70(294)	194(1338)	73(80)	0.35 (8.9)	Bend	0.75 (19.1)	0.75(19.1)	---	

COMPOSITION

	C	Mn	Si	Cr	Mo	V	P	S
A	0.43	0.25	0.96	5.12	1.33	0.57	0.010	0.007
B	0.39	0.31	0.90	4.91	1.30	0.51	0.016	0.010
C	0.38	0.35	0.96	4.99	1.36	0.50	0.010	0.007
D	0.37	0.28	0.93	5.15	1.20	0.43	0.009	0.008
E	0.40	0.35	0.87	4.90	1.27	0.51	0.021	0.008

HEAT TREATMENT

- 1850F (1263K), 20 min; Temper 2 Hr + 2 Hr, 1050F (839K)
- 1850F (1283K), 20 min; Temper 2 Hr + 2 Hr, 1100F (867K)
- 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr, 1080F (856K)
- 1850F (1283K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr, 1100F (867K)
- 1550F (1117K), 1 Hr, Oil Quench; Temper 2 Hr + 2 Hr, 950F (783K), Air Cool

COMPOSITION

HEAT TREATMENT

1. 1850F (1253K), 20 min; Temper 2 Hr + 2 Hr, 1050F (839K)
2. 1850F (1253K), 20 min; Temper 2 Hr + 2 Hr, 1100F (867K)
3. 1850F (1253K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr, 1080F (856K)
4. 1850F (1253K), in Salt, Oil Quench; Temper 1 Hr + 1 Hr, 1100F (867K)
5. 1550F (1117K), 1 Hr, Oil Quench; Temper 2 Hr + 2 Hr, 950F (763K), Air Cool

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Steel, Low Alloy: AISI 4140

Table 4

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (N/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 $\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Bar: 1 in (25.4 mm) Thick	A, 1	L-T	200(367)	173(1193)	65(72)	0.553 (9.0)	Bend 4 pt	1.03 (26.2)	1.0 (25.4)	0.321 (8.2)	7
	A, 1	L-T	75(297)	196(1310)	72(79)	0.559 (9.1)	Bend 4 pt	1.03 (26.2)	1.0 (25.4)	0.225 (5.7)	
	B, 1	T-L	75(297)	---	70(77)	---	Bend 4 pt	1.02 (25.9)	1.0 (25.4)	0.3 (7.6)	
	B, 1	L-T	-50(228)	200(1379)	65(72)	0.324 (8.2)	Bend 4 pt	1.02 (25.9)	1.0 (25.4)	0.33 (8.4)	
Plate: 1 in (25.4 mm) Thick	B, 1	L-T	-100(200)	205(1413)	52(57)	0.161 (4.1)	Bend 4 pt	1.02 (25.9)	1.0 (25.4)	0.24 (6.1)	
	C, 2	T-L	70(294)	177(1220)	90(99)	0.782 (19.9)	SIN 4 pt	1.0 (25.9)	4.5 (114)	1.6 (40.6)	21
Plate: 4 in (101.6 mm) Thick	D, 3	L-T	75(297)	66(455)	55(60)	1.736 (44.1)	WOL	4.0 (102)	10.22 (260)	4.0 (102)	45
		L-T	0, -60	82(565)	52(57)	1.005 (25.5)	WOL	4.0 (102)	10.22 (260)	3.1 (78.7)	

COMPOSITION

	C	Mn	P	S	Si	Cr	Mo	Ni	V	Cu
A	0.37	0.75	0.010	0.019	0.26	0.85	0.15	---	---	---
B	0.38	0.81	0.008	0.025	0.27	0.91	0.17	---	---	---
C	0.43	0.98	0.013	0.030	0.19	1.04	0.21	0.01	0.08	---
D	0.42	0.78	0.007	0.023	0.23	0.89	0.21	0.22	<0.01	0.25

HEAT TREATMENT

1. Austenitize 1550F (1117K) in Salt, Oil Quench, Temper 800F (700K), 2 hr
2. Austenitize 1550F (1117K), 1 Hr, Oil Quench, Temper 900F (756K), 2 Hr, Air Cool
3. Austenitize 1550F (1117K), 6 Hr, Oil Quench; Temper 1200F (922K), 6 Hr, Furnace Cool

STEEL, Low Alloy: AISI 4140 (Sheet 1 of 2)

Table 5

Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{3/2})	2.5 /K _{IC} ² (σ _{ys} in (mm))	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 0.125 in (3.2 mm) Thick	A,1	L-T	200(367)	220(1517)	40(44)	0.083 (2.1)	CC	0.10 (2.5)	3.0 (76.2)	1.2 (30.5)	8
	A,2	L-T	-100(200)	220(1517)	40(44)	0.083 (2.1)	CC	0.10 (2.5)	3.0 (76.2)	1.2 (30.5)	
Plate: 0.375 in (9.5 mm) Thick	B,3	L-T	200(367)	208(1435)	60(66)	0.208 (5.3)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	7
	E,3	L-T	75(297)	226(1517)	52(57)	0.140 (3.6)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	
	F,3	T-L	75(297)	223(1538)	53(58)	0.141 (3.6)	Bend	0.377(9.6)	0.9 (22.9)	0.37 (9.4)	
	E,3	L-L	-50(228)	235(1620)	40(44)	0.072 (1.8)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	
	E,3	L-T	-100(200)	240(1655)	32(35)	0.044 (1.1)	Bend	0.390(9.9)	1.0 (25.4)	0.4 (10.1)	
Plate: 0.500 in (12.6 mm) Thick	H,10	T-L	75(297)	231(1593)	68(75)	0.217 (5.5)	Bend	0.500(12.7)	1.0 (25.4)	--- ---	80
Plate: 0.625 in (15.9 mm) Thick	C,4	L-T	75(297)	204(1504)	78(86)	0.371 (9.4)	SEN	0.523(13.3)	2.0 (50.8)	0.67 (17.6)	12
Plate: 1 in (25.4 mm) Thick	D,5	L-T	70(294)	182(1255)	106(116)	0.850 (21.6)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	6
	D,6	L-T	70(294)	213(1469)	68(75)	0.255 (6.5)	Bend	1.0 (25.4)	1.0 (25.4)	0.5 (12.7)	
	B,7	L-T	-50(228)	203(1380)	65(71)	0.256 (6.5)	Bend	1.0 (25.4)	1.0 (25.4)	0.2 (5.1)	7
		L-T	-100(200)	206(1400)	50(55)	0.148 (3.8)	Bend	1.0 (25.4)	1.0 (25.4)	0.2 (5.1)	
	D,8	L-T	70(294)	230(1586)	52(57)	0.128 (3.3)	Bend	0.25 (6.3)	1.0 (25.4)	0.5 (12.7)	9
	D,7	L-T	75(297)	206(1400)	80(88)	0.38 (9.7)	Bend	0.95 (24.2)	2.0 (50.8)	1.0 (25.4)	44
Billet: 4x4.5 in (102x 114 mm) Vac. Arc Remelted	G,9	L-T	72(296)	241(1662)	53(58)	0.121 (3.1)	Bend	0.90 (22.9)	1.8 (45.7)	0.9 (22.9)	79
		T-L	72(296)	240(1655)	54(59)	0.127 (3.2)	Bend	0.90 (22.9)	1.8 (45.7)	0.9 (22.9)	
		T-S	72(296)	240(1655)	56(62)	0.136 (3.5)	Bend	0.90 (22.9)	1.8 (45.7)	0.9 (22.9)	
Forged Bar: 5 in (127 mm) Thick	I,11	T-S	70(294)	191(1317)	80(88)	0.439 (11.1)	(a)	---	---	---	69
	I,12	T-S	70(294)	230(1586)	49(53)	0.113 (2.9)	(a)	---	---	---	

(a) Specimen in accordance with ASTM Recommendations

Table 5 (Cont.)

Form	Composition, Heat Treatment							Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{-3/2})	2.5 (K _{IC} σ _{ys}) ² in (mm)	Specimen			Ref.
	C	Mn	P	S	Si	Ni	Cr					Mo	Type	Thickness in (mm)	
COMPOSITION:															
A	0.41	0.72	0.015	0.009	0.33	1.83	0.78	0.26							
B	0.43	0.84	0.006	0.005	0.27	1.78	0.78	0.26							
C	0.43	0.65	0.010	0.005	0.30	1.85	0.82	0.26							
D	0.42	0.71	0.010	0.012	0.25	1.77	0.80	0.23							
E	0.40	0.75	0.005	0.010	0.29	1.77	0.79	0.25							
F	0.41	0.69	0.018	0.012	0.29	1.87	0.78	0.22							
G	0.42	0.84	0.008	0.005	0.25	1.71	0.82	0.24							
H	0.38	0.74	0.001	0.005	0.28	1.86	0.84	0.26							
I	0.43	0.63	0.013	0.004	0.24	1.56	1.03	0.30							
HEAT TREATMENT															
1. Normalize 1600F (1144K), 1 Hr; Austenitize 1550K (1117K), 1 Hr, Oil Quench; Temper 1 Hr, 400F (478K)															
2. Normalize 1600F (1144K), 1 Hr, Austenitize 1550F (1117K), 1 Hr, Oil Quench; Temper 1 Hr, 700F (664K)															
3. 1550F (1117K) Salt; Oil Quench; Temper 1 Hr + 1 Hr, 500F (533K)															
4. 1500F (1089K), 1 Hr; Temper 1 Hr + 1 Hr, 700F (644K)															
5. 1500F (1089K), 0.5 Hr; Oil Quench; Temper 1 Hr, 925F (770K)															
6. 1500F (1089K), 0.5 Hr; Oil Quench; Temper 1 Hr, 750F (672K)															
7. 1550F (1117K) Salt, Oil Quench; Temper 1 Hr + 1 Hr, 800F (700K)															
8. 1500F (1089K), 0.5 Hr, Oil Quench; Temper 1 Hr, 600F (589K)															
9. 1650F (1172K), 1 Hr, Air Cool; 1550F (1089K), 1 Hr, Oil Quench; -321F (77K), 0.5 Hr Min; 400F (478K), 2 Hrs															
10. 1600F (1144K), 0.5 Hr, Air Cool; 1500F (1089K), 0.5 Hr, Oil Quench; -320F, 0.5 Hr, 400F (478K), 6 Hr, Air Cool; 250F (394K), 24 Hr, Air Cool															
11. 1543F (1113K), 0.5 Hr, Oil Quench; Temper 841F (723K), 0.75 Hr															
12. 1543F (1113K), 0.5 Hr, Oil Quench; Temper 571F (573K), 1 Hr															

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STEEL, Low Alloy: 30QM (Sheet 1 of 2)

Table 6

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} KSI \sqrt{in} (MN \sqrt{m})	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Forging: 5 x 10 in (152 x 254 mm)	A,1	L-T	70(294)	246(1703)	69(75)	0.195 (5.0)	Bend	---	---	---	19
Forging: 4.5 x 4.5 in (114 x 114 mm)	B,2	L-T	70(294)	243(1675)	60(65)	0.152 (3.9)	Bend	0.50 (12.7)	1.0 (25.4)	0.5 (12.7)	16
Forging: 1 x 13 x 34 in (25.4 x 330.2 x 863.6 mm)	C,3	L-T	70(294)	240(1655)	88(96)	0.336 (8.5)	CC	0.372(9.4)	5.0 (127)	1.90 (1.90)	18
	C,4	L-T	70(294)	234(1613)	74(81)	0.250 (6.4)	CC	0.370(9.4)	5.0 (127)	2.05 (52.1)	
	C,5	L-T	70(294)	205(1413)	74(81)	0.336 (8.3)	CC	0.370(9.4)	5.0 (127)	1.75 (44.4)	
Forging: 3 x 9 in (76.2 x 229.6 mm)	D,6	T-L	70(294)	233(1606)	79(87)	0.287 (7.3)	Bend	0.480(12.2)	1.5 (38.1)	0.30 (7.6)	3
Hot Rolled							4 pt				
2300F (1533K)							Bend	0.480(12.2)	1.5 (38.1)	0.30 (7.6)	
Forged 2100F (1422K)		T-L	-65(219)	233(1606)	53(58)	---	4 pt				
Forging: 20 in (508 mm) dia Ingot	E,6	T-L	70(294)	236(1627)	68(74)	0.208 (5.3)	Bend	0.480(12.2)	1.5 (38.1)	0.30 (7.6)	
Forged at 2125F (1436K) to 3 x 9 in (76.2 x 228.6 mm)		T-L	-65(219)	---	45(49)	---	Bend	0.480(12.2)	1.5 (38.1)	0.30 (7.6)	
Billet: 3 in (76.2 mm)	F,7	L-TS	70(294)	142(976)	111(122)	1.33 (38.8)	(a)	---	---	---	57
	F,8	L-TS	70(294)	185(1275)	111(122)	0.9 (22.9)	(a)	---	---	---	
	F,9	L-TS	70(294)	206(1418)	78(86)	0.358 (9.1)	(a)	---	---	---	
	F,10	L-R	70(294)	238(1643)	68(75)	0.209 (5.3)	(a)	---	---	---	67
Bar: Vacuum Arc Remelted 1 in (25.4 mm) Dia	G,11	C-R	70(294)	255(1755)	45(50)	0.078 (2.0)	(a)	---	---	---	68
Forged Bar: Vacuum Arc Remelted 5 in (127 mm) Dia	H,12	L-T	72(296)	259(1785)	52(57)	0.101 (2.6)	Bend	0.9(22.9)	1.8 (45.7)	0.9 (22.9)	79
Billet: 4 x 4.5 in (101 x 114 mm)		T-L	72(296)	255(1758)	56(62)	0.121 (3.1)	Bend	0.9(22.9)	1.8 (45.7)	0.9 (22.9)	79
		T-L	72(296)	255(1758)	58(64)	0.129 (3.3)	Bend	0.9(22.9)	1.3 (45.7)	0.9 (22.9)	79

(a) Specimen in accordance with ASTM Recommendations

Table 6 (Cont.)

Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MJ/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) in (mm)	Specimen				
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref
Plate: 0.56 in (14.2 mm) Thick											
	J, 13	L-T	70 (294)	248 (1710)	50 (66)	0.146 (3.7)	Bend 0.5	12.7	1.5 (38.1)	-	123
	J, 14	L-T	70 (294)	233 (1606)	60 (72)	0.2 (5.1)	Bend 0.5	12.7	1.5 (38.1)	-	
COMPOSITION											
	C	Si	Mn	S	P	Ni	Cr	V	Al		
A	0.43	1.68	0.70	0.010	0.010	0.39	1.93	0.79	0.07	0.15	
B	0.41	1.77	0.81	0.003	0.007	0.40	1.85	0.83	0.08	-	
C	0.40	1.60	0.83	0.006	0.007	0.41	1.82	0.83	0.09	-	
D	0.39	1.55	0.82	0.009	0.012	0.43	1.73	0.86	0.09	-	
E	0.43	1.62	0.85	0.006	0.014	0.41	1.74	0.94	0.08	-	
F	0.42	1.45	0.73	0.006	0.009	0.40	1.82	0.98	0.11	0.029	
G	0.44	1.63	0.81	0.006	0.005	0.38	1.34	0.85	0.09	-	
H	0.42	1.59	0.80	0.006	0.006	0.37	1.81	0.79	0.08	-	
J	0.43	1.72	0.84	0.004	0.010	0.39	1.72	0.77	0.08	-	
HEAT TREATMENT											
1.	1600F (1144K), Quenched Warm Oil; Double Temper 2 + 2 Hr, 575F (575K)										
2.	1700F (1200K), 3 1/2 Hr, Air Cool; 1600F (1144K), 1 1/2 Hr; Salt Quenched to 1000F, Hold 1 Hr; Oil Quenched; 110F, 1/2 Hr; Double Tempered 575F (575K), 2 + 2 Hr Air Cool										
3.	1700F (1200K), 1 1/2 Hr, Air Cool; 1600F (1144K), 1 1/2 Hr, Oil Quenched; Double Temper, 2 + 2 Hr, 500F (533K)										
4.	1700F (1200K), 1 1/2 Hr, Air Cool; 1600F (1144K), 1 1/2 Hr, Oil Quenched, Double Temper, 2 + 2 Hr, 675F (630K)										
5.	1700F (1200K), 1 1/2 Hr, Air Cool; 1600F (1144K), 1 1/2 Hr, Oil Quenched, Double Temper, 2 + 2 Hr, 975F (797K)										
6.	1600F (1144K), 1 Hr, Oil Quenched; Double Temper, 3 + 3 Hr, 600F (589K), Air Cool										
7.	1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 1200F (922K), 2 + 2 Hr										
8.	1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 1111F (873K), 2 + 2 Hr										
9.	1705F (1203K), Air Cool; 1777F (1243K), Oil Quench; 1021F (823K), 2 + 2 Hr										
10.	1705F (1203K), Air Cool; 1777F (1243K), Oil Quench, 481F (523K), 2 + 2 Hr										
11.	1705F (1203K), Air Cool; 1615F (1153K), Oil Quench; 571F (573K), 5 + 5 Hr										
12.	1700F (1200K), 1 Hr, Air Cool; 1600F (1144K), 1 Hr, Oil Quench, -321F (77K), 0.5 Hr Min; 600F (589K), 2 + 2 Hr										
13.	1550F (1117K), Oil Quench; 550F (561K), 2 + 2 Hr										
14.	1600F (1144K), Oil Quench; 550F (561K), 2 + 2 Hr										

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STEEL, Low Alloy: D6AC (Sheet 1 of 2)

Table 7

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°C)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 / K _{IC} ² (σ _{ys}) in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 0.095 in (2.4 mm) Thick	A,1	T-L	75(297)	236(1628)	46(50)	0.095(2.4)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)	12
		L-T	-100(200)	253(1745)	37(41)	0.063(1.3)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)	
		L-T	-200(144)	263(1815)	36(40)	0.047(1.2)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)	
Plate: 0.5 in (12.7 mm) Thick	B,2	L-S	70(294)	203(1400)	110(120)	0.734(18.6)	Bend	0.75 (19.1)	1.5 (38.1)	0.368(9.3)	20
		L-S	70(294)	231(1523)	61(66)	0.174(4.4)	Bend	0.257(6.5)	0.486(12.3)	0.245(6.2)	
Plate: 0.75 in (19.1 mm) Thick	B,1	---	70(294)	247(1703)	67(74)	0.735(18.7)	Bend	0.75 (19.1)	0.75 (19.1)	---	46
Plate: 0.8 in (20.3 mm) Thick	C,3	---	175(353)	211(1455)	92(101)	0.475 (12.1)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	51
		---	70(294)	217(1496)	94(103)	0.469 (11.9)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	-20(244)	226(1558)	72(79)	0.254 (6.4)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Plate: 1.5-1.8 in (38.1-45.7 mm) Thick		---	175(353)	211(1455)	92(101)	0.475 (12.1)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	70(294)	217(1496)	79(87)	0.331 (8.4)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	-20(244)	226(1558)	50(55)	0.122 (3.1)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Forging: 0.8 in (20.3 mm) Thick 1.5-1.8 in (38.1-45.7 mm) Thick		---	-65(219)	228(1572)	46(51)	0.102 (2.6)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	70(294)	214(1476)	97(107)	0.514 (13.0)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		---	70(294)	214(1476)	90(99)	0.442 (11.2)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Billet: 3 in (76.2 mm) Dia	D,4	---	-65(219)	225(1551)	45(50)	0.100 (2.5)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
		LR	70(294)	208(1454)	105(115)	0.637 (16.2)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	67
		LR	70(294)	215(1482)	84(92)	0.382 (9.7)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
COMPOSITION											
	C	Mn	P	S	Si	Ni	Cr	Mo	V	Al	
A	0.47	0.85	0.007	0.005	0.20	0.57	1.07	1.01	0.08	0.06	
B	0.45	0.69	0.008	0.006	0.026	0.55	1.08	1.01	0.08	0.07	
C	0.475N	0.75N	0.015M	0.015M	0.22N	0.55N	1.0N	1.0N	0.12N	---	
D	0.47	0.90	0.010	0.007	0.30	0.55	1.0	0.92	0.10	0.026	

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Table 7 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{-3/2})	2.5 (K _{IC}) ² in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)

HEAT TREATMENT

- 1650F (1172K); 1550F (1117K), Oil Quenched 150F (339K); Temper 1 Hr + 1 Hr, 500F (533K)
- 1550F (1117K) in Salt, 20 min, Oil Quench, Temper 1 Hr + 1 Hr, 500F (533K)
- 1700F (1200K); Quench in Furnace to 975 + 25F (797 + 14K), at 6F (3.3K) per minute from 1350 to 1150F (1006 to 894K), Oil Quench 140F (334K); Temper 1000-1025F (811-823K), 1 Hr + 1 Hr
- 1705F (1203K), Air Cool; 1615F (1153K), Oil Quench at 363F (457K), 1 Hr;
- Temper 841F (723K), 2 Hr
- 1705 (1203K), Air Cool; 1615 F (1153K), Oil Quench at 363F (457K), 1 Hr; Temper 1021F (823K), 2 Hr

SILFEL, Low Alloy: EN24, Ni-Cr-Mo-V

Form		Composition, Heat Treatment	Test Orientation	Temp °F (°K)		Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 (K _{IC} ² / σ _{ys}) in (mm)	Specimen				Ref.
									Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
EN24 Ingot: 5 in (127 mm) Sq.	A, 1	L-ST	70(294)	231(1590)	64(70)	0.192 (4.9)	Bend 0.492 (12.5)	0.084 (25)	-	-	91		
	A, 2		70(294)	220(1520)	37(41)	0.071 (1.8)	Bend 0.482 (12.5)	0.984 (25)					
	A, 3		70(294)	206(1420)	75(83)	0.331 (8.4)	Bend 0.482 (12.5)	0.984 (25)					
	A, 4		70(294)	206(1420)	41(45)	0.099 (2.5)	Bend 0.482 (12.5)	0.984 (25)					
	A, 5		70(294)	186(1285)	71(78)	0.364 (9.3)	Bend 0.482 (12.5)	0.984 (25)					
Ni-Cr-Mo-V Bar 1.0 x 3.312 in (25.4 x 7.9 mm)	B, 6	L	70(294)	263(1837)	45(48)	0.074 (1.9)	Bend 0.187 (4.7)	0.75 (19.1)	---	---	47		
	B, 7	L	70(294)	251(1753)	49(53)	0.096 (2.4)							
	B, 8	L	70(294)	241(1683)	51(56)	0.112 (2.8)							
	B, 9	L	70(294)	247(1725)	67(73)	0.185 (4.7)							
	B, 10	L	70(294)	236(1648)	63(69)	0.180 (4.6)							

COMPOSITION

C	Mn	Si	P	S	Ni	Cr	Mo	Sn	Cu	Al	V
A	0.39	0.57	0.28	0.021	0.058	1.76	1.10	0.24	0.023	0.16	0.020
B	0.45	0.44	0.79	0.012	0.068	1.72	1.31	0.88	-	-	0.23
C	0.39	1.15	1.45	0.008	0.006	1.90	0.09	0.30	-	-	0.24

HILAI TREATMENT

1.	1543K (1113K), Hold 40 Sec, Oil Quench, 7 cycles; 1596F (1135K), Hold 1 min, Oil Quench, 2 cycles; 661F (623K), 4 Hr
2.	1561F (1123K), 4 Hr, Oil Quench; 181F (523K), 1 Hr
3.	1561F (1123K), Hold 1 min, Oil Quench, 1 cycle; 661F (623K), 4 Hr
4.	1561F (1123K), 1 Hr, Oil Quench; 661F (623K), 1 Hr
5.	1561F (1123K), 1 Hr, Oil Quench, 841F (723K), 1 Hr
6.	1690F (1193K), Oil Quench; refrigerated at -95F (203K); Tempered 481F (523K)
7.	1690F (1193K), Oil Quench; refrigerated at -95F (203K); Tempered 571F (573K)
8.	1690F (1193K), Oil Quench; refrigerated at -95F (203K); Tempered 661F (623K)
9.	1561F (1123K), Oil Quench; temper 706F (648K)
10.	1561F (1123K), Oil Quench; Temper 481F (523K)

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COMPOSITION

	C	Mn	Si	P	S	Al	Fe	Ni	Mo	Sn	Cu	Al	V
A	0.39	0.57	0.28	0.021	0.038	1.76	1.10	0.24	0.023	0.16	0.020	-	-
B	0.45	0.44	0.79	0.012	0.008	1.72	1.31	0.88	-	-	-	-	0.23
C	0.39	1.15	1.45	0.008	0.006	1.90	0.09	0.30	-	-	-	-	0.24

HEAT TREATMENT

1. 1545K (1113K), Hold 40 Sec, Oil Quench, 7 cycles; 1506F (1133K), Hold 1 min, Oil Quench, 2 cycles; 661F (623K), 4 Hr
2. 1561F (1123K), 4 Hr, Oil Quench; 181F (523K), 1 Hr
3. 1561F (1123K), Hold 1 min, Oil Quench, 1 cycle; 661F (623K), 4 Hr
4. 1561F (1123K), 1 Hr, Oil Quench; 661F (623K), 1 Hr
5. 1561F (1123K), 1 Hr, Oil Quench; 661F (623K), 1 Hr
6. 1690F (1193K), Oil Quench; refrigerated at -95F (203K); Tempered 481F (523K)
7. 1690F (1193K), Oil Quench; refrigerated at -95F (203K); Tempered 571F (573K)
8. 1690F (1193K), Oil Quench; refrigerated at -95F (203K); Tempered 571F (573K)
9. 1561F (1123K), Oil Quench; temper 706F (648K)
10. 1561F (1123K), Oil Quench; Temper 481F (523K)

Table 9

Form	Composition, Heat Treatment	Orientation	Temp of test (°K)	Yield Strength (ksi (N/mm ²))	Typical K _{IC} ASIV/in (MN/m ^{3/2})	2σ _{ys} ($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				
							Type	Thickness in mm	Width in (mm)	Crack Length in (mm)	Ref
Plate: 1.5 in (38.1 mm) Thick	A, 1	I-L	-100 (200)	98 (1365)	132 (145)	1.11 (28.2)	Bend	1.4 (35.5)	2.8 (7.1)	1.4 (35.5)	4
			-321 (78)	240 (1655)	49 (54)	0.10 (2.6)	Bend	1.4 (35.5)	2.8 (7.1)	1.4 (35.5)	
Plate: 2.5 in (63.5 mm) Thick	A, 2	I-L	73 (246)	150 (1310)	142 (156)	1.53 (38.9)	CT	2.0 (50.8)	6.0 (152)	2.9 (73.7)	110
Plate: 4 in (101.6 mm) Thick	B, 2	S-L	85 (302)	186 (1283)	122 (136)	0.98 (24.9)	CT	1.0 (25.4)	3 (76.2)	1.5 (38.1)	

COMPOSITION:

	C	Si	Co	Mn	Pb	Cr	P	S	Cu
A	0.21	8.90	4.24	0.20	0.02	0.74	0.07	0.005	0.01
B	0.19	9.40	1.52	0.29	0.90	0.85	0.10	0.005	0.05

HEAT TREATMENT

1. Normalize 1650f (9172k), 1.5 hr, Air (cool), Austenitize 1500f (1089K), 1.5 hr Water Quench; Temper 1025f (823k), 6 hr.

2. 1525f (8102k), 0.1 Quench; -100f (200K), 1 hr; 1025f (823k), 6 hr

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STEEL, Nickel: 9Ni-4Co-.3C

Table 10

Form	Composition, Heat Treatment	Test Orientation	Temp ϕ_F (°C)	Yield Strength KSI (MN/m ²)	Typical K_{IC} (KSI/in (MN m ^{-3/2}))	2.S. ($\frac{K_{IC}}{\sigma_{ys}}$) in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 3 in (76.2 mm) Thick	A, 1	T-L	82 (300)	215 (1482)	88 (5.0)	0.44 (11.2)	CT	1.0 (25.4)	3.0 (76.2)	1.5 (38.1)	110
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm)	B, 2	L-T	70 (294)	223 (1535)	99 (110)	0.49 (12.5)	DEC	5.0 (12.7)	3.0 (76.1)	0.5 (12.7)	16
Forging: 3 in (76.2 mm) Thick	C, 3	L-T	-100 (200)	202 (1392)	64 (69)	0.25 (6.4)	DEC	0.50 (12.7)	3.0 (76.1)	0.5 (12.7)	11
		T-L	150 (339)	175 (1366)	108 (123)	0.95 (24.2)	WOL	2.0 (50.8)	5.1 (130)	1.8 (45.7)	
		T-L	70 (294)	177 (1220)	177 (1366)	1.61 (41.0)	WOL	2.0 (50.8)	2.25 (57.3)	1.0 (25.4)	
		T-L	70 (294)	177 (1220)	100 (110)	0.78 (20.3)	WOL	2.0 (50.8)	5.1 (130)	1.8 (45.7)	
		T-L	0 (355)	187 (1289)	105 (114)	0.788 (20.0)	WOL	2.0 (50.8)	5.1 (130)	1.8 (45.7)	
		T-L	-40 (233)	188 (1296)	111 (121)	0.871 (22.1)	WOL	2.0 (50.8)	5.1 (130)	1.8 (45.7)	
		T-L	-75 (214)	188 (1296)	112 (122)	0.888 (22.6)	WOL	2.0 (50.8)	5.1 (130)	1.8 (45.7)	

COMPOSITION

	C	Ni	Co	Mn	Mo	Cr	V	P	S	Si
A	0.21	8.90	4.24	0.20	0.92	0.74	0.07	0.009	0.007	0.01
B	0.32	7.62	4.25	0.16	0.94	1.03	0.08	0.005	0.007	0.01
C	0.26	8.41	3.9	0.33	0.48	0.40	0.07	0.008	0.008	0.01

HEAT TREATMENT

1. 1525 (1103K), Oil Quench; -100F (200K), 3 Hr; 1000F (811K), 5 Hr
2. 1125F (882K) 16 Hr, Air Cool; 1700F (1200K) 1 Hr, Air Cool; 1550F (1115K), 0.5 Hr, Salt Quench to 460F (512K); Hold 7 Hr; Temper 1000F (811K) 2 Hr, Air Cool
3. 1550F (1175K), 2 Hr; Double Temper, 2 Hr + 2 Hr, 1000F (811K)

STEEL, NICKEL: 9Ni-4Co-.45C

Table 11

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K_{IC} KSI√in (MN m ^{-3/2})	2.5 ($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
Plate: 0.95 in (2.4 mm) Thick	A,1	L-T	75(297)	220(1510)	50(55)	0.125(3.2)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)
		T-L	75(297)	224(1545)	50(55)	0.124(3.2)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)
		L-T	-100(200)	223(1540)	51(56)	0.131(3.3)	CC	0.095(2.4)	1.75 (44.4)	0.7 (17.8)
		L-T	-200(144)	226(1575)	47(52)	0.106(2.7)	CL	0.095(2.4)	1.75 (44.4)	0.7 (17.8)
		T-L	75(297)	233(1610)	86(95)	0.34 (8.6)	Bend	0.875(22.2)	0.875(22.2)	---
Plate: 1 in (25.4 mm) Thick	B,2	T-L	75(297)	233(1610)	86(95)	0.34 (8.6)	Bend	0.875(22.2)	0.875(22.2)	---
		L-T	70(294)	198(1365)	109(120)	0.755(19.2)	CC	1.0 (25.4)	9.0 (228.6)	2.6 (60)
Forging: 9 x 9 x 24 in (228.6 x 228.6 x 609.6 mm)	C,3	L-T	-110(194)	211(1453)	55(60)	0.172(4.3)	CC	1.0 (25.4)	9.0 (228.6)	2.6 (60)
		T-L	70(294)	225(1550)	90(98)	0.4 (10.2)	Bend	0.480(12.2)	1.5 (38.1)	0.31(7.9)
Forging: 3 x 9 x 24 in (76.2 x 228.6 x 609.6 mm)	D,4	T-L	-65(219)	---	68(75)	---	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.33(8.4)
		T-L	300(422)	195(1344)	83(90)	0.453(11.5)	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.36(9.1)
Forging: 3 x 9 x 24 in (76.2 x 228.6 x 609.6 mm)	E,5	T-L	75(257)	225(1550)	89(97)	0.392(10.0)	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.31(17.9)
		L-T	-65(219)	246(1655)	89(97)	0.344(8.7)	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.32(8.1)
		T-L	-65(219)	---	68(75)	---	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.33(8.4)
		S-L	-64(219)	---	79(87)	---	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.36(9.1)
		T-L	-110(194)	243(1675)	62(68)	0.163(4.1)	4 pt Bend	0.480(12.2)	1.5 (38.1)	0.35(8.9)

COMPOSITION

	C	Ni	Co	Mn	Mo	Cr	V	P	S	Si
A	0.45	8.76	3.76	0.12	0.30	0.30	0.06	0.005	0.009	0.01
B	0.43	8.00	4.0	0.02	0.08	0.09	0.12	---	---	0.01
C	0.43	8.09	3.81	0.13	0.11	0.13	0.09	0.005	0.009	0.01
D	0.45	7.90	4.26	0.09	0.22	0.33	0.10	0.003	0.011	0.05
E	0.44	7.79	4.03	0.19	0.29	0.32	0.08	0.010	0.009	0.05

HEAT TREATMENT

1. 1450F (1060K), Oil Quench; Temper 1 hr + 1 hr, 600F (589K)
2. 1600F (1144K), Air Cool; 1450F (1061K) 0.5 hr, Salt Bath
3. 1600F (1144K), 1 hr, Air Cool; 1450F (1061K), 30 min; Salt Quench, 450F (505K), 6 hr, Air Cool; Double Temper 1 hr + 1 hr, 700F (644K)
4. 1500F (1089K), 1 hr, Salt Quench 475F (519K) 6 hr
5. 1550 - 1650F (1117-1172K) 1 hr, Air Cool; 1150F (894K), 30 min; 1500F (1089K) 1 hr; 465F (514K) Salt Bath, 6 hr, Air Cool

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STEEL: 10 Nickel

Table 12

Table 12											
Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 (K _{IC} ² / σ _{ys}) in (mm)	Specimen				Ref.
							Type	Thickness in. (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 0.5 in (12.7 mm) Thick	A, 1	L-T	70(294)	257(1772)	51(56)	0.98 (2.5)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	80
		T-L	70(294)	256(1765)	52(57)	0.103 (2.6)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
	B, 2	T-L	70(294)	256(1765)	87(96)	0.352 (8.9)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
	C, 2	T-L	70(294)	272(1875)	73(80)	0.216 (5.5)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
	D, 5	T-L	70(294)	257(1772)	77(85)	0.618 (15.7)	Bend	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	Al	N	O	Co
A	0.26	0.15	0.001	0.003	0.12	10.08	2.00	0.98	0.008	0.002	0.01	15.2
B	0.23	0.13	0.001	0.002	0.13	9.68	1.94	0.98	9.002	0.003	0.001	12.3
C	0.25	0.14	0.002	0.003	0.11	10.10	1.99	1.01	0.004	0.002	0.001	14.6
D	0.25	0.11	0.001	0.003	0.12	10.0	1.57	0.79	0.004	0.001	0.002	12.6

HEAT TREATMENT

- 1650F (1172K), 1 Hr, Water Quenched; 1500F (1089K), 1 Hr., Water Quench; Temper 950F (783K), 1 Hr, Water Quench.
- Heat to 1350F (839K), Hold, Heat to 1550F (1117K), Hold, Water Quench, Repeat Cycle 4 Times, Temper 950F (783K), 5 Hr
- Heat to 1120F (879K), Hold 6 Sec, Heat to 1450F (1060K), Hold 8 Sec, Water Quench, Repeat Cycle 4 Times, Temper 400F (478K), 5 Hr

STEEL: Maraging 12 Nickel

Table 13

Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 (K _{IC} ²) in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 1 in (25.4 mm) Thick	A,1	L-T	70(294)	171(1179)	100(110)	0.86 (21.8)	SEN	1 (25.4)	4.5 (114.3)	1.6 (40.7)	21
	B,1	T-L	70(294)	185(1276)	120(132)	1.175 (29.9)	SEN	1 (25.4)	4.5 (114.3)	1.6 (40.7)	
Plate: 2 in (50.8 mm) Thick	C,1	L-T	20(294)	175(1207)	125(138)	1.28 (32.5)	Bend	2 (50.8)	5.95(151)	1.6 (40.7)	85
	D,2	-	70(294)	186(1282)	147(162)	1.56 (39.6)	4 pt Bend	2 (50.8)	2 (50.8)	-	85

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	Ti	Al
A	0.033	0.08	0.007	0.005	0.07	12.5	4.81	3.55	0.21	0.16
B	0.033	0.08	0.007	0.005	0.07	12.5	4.71	3.65	0.21	0.16
C	0.23	0.088	0.004	0.008	0.094	12.1	5.21	2.86	0.24	-
D	0.24	0.044	0.007	0.013	0.042	11.72	5.38	3.18	0.30	0.47

HEAT TREATMENT

1. 1500F (1089K); Temper 900F (756K), 3 hr
2. 1500F (1089K); Temper 900F (756K), 30 hr

STEEL: 18Ni: Maraging: 200 Grade

Table 14

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 /K _{IC} ² (in (mm) (°K) (°C) ²)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 1 in (25.4 mm) Thick	A, 1	L-T	-321(18)	241(1662)	115(127)	0.569 (14.5)	Bend	1.0 (25.4)	3.0 (76.2)	1.6 (40.6)	10
Plate: 2 in (50.8 mm) Thick	-2	L-T	75(297)	187(1289)	152(167)	1.65 (42.0)	Bend	2.0 (50.8)	4.0 (101.6)	1.5 (38.1)	85
Plate: 2 in (50.8 mm) Thick	D, 3	L-S	70(294)	197(1356)	104(114)	0.697 (17.7)	(a)	---	---	---	71
		L-T	70(294)	192(1324)	100(110)	0.687 (17.2)	(a)	---	---	---	
		T-S	70(294)	194(1334)	78(86)	0.404 (10.3)	(a)	---	---	---	
		T-L	70(294)	195(1347)	75(83)	0.370 (9.4)	(a)	---	---	---	
		S-L	70(294)	198(1365)	70(75)	0.312 (7.9)	(a)	---	---	---	
Plate: 2.13 in (54mm) Thick	B, 4	T-L	75(297)	206(1420)	170(187)	1.7 (43.2)	Bend	2.0 (50.8)	4.0(101.6)	2.0(50.8)	4
		T-L	-100(200)	229(1580)	164(179)	1.28 (32.5)	Bend	2.0 (50.8)	4.0(101.6)	2.0(50.8)	
		T-L	-321(78)	271(1870)	79(87)	0.21 (5.3)	Bend	2.0 (50.8)	4.0(101.6)	2.0(50.8)	
Plate: 4.25 in (108 mm) Thick Con.El. Vac Remelt, Hot Rolled at 2300F (1553K)	C, 5	L-T	75(297)	234(1613)	92(101)	0.386 (9.8)	Bend	3.94 (100)	7.89(200)	4.0 (102)	78
	C, 6	L-T	75(297)	211(1455)	103(113)	0.596 (15.1)	CT	3.94 (100)	6.31(160)	3.22 (81.6)	
	C, 7	L-T	75(297)	190(1310)	129(142)	1.152 (2.93)	Bend	3.94 (100)	7.87(200)	3.92 (99.6)	
	C, 8	L-T	75(297)	174(1200)	180(198)	2.675 (68.0)	Bend	3.93 (100)	7.86(200)	3.98 (101)	
	C, 9	L-T	75(297)	166(1145)	187(206)	3.173 (80.6)	CT	3.93 (100)	6.31(160)	3.20 (81.3)	

HEAT TREATMENT

(a) Specimen in accordance with ASTM Recommendations

COMPOSITION

	C	Mn	P	S	Si	Ni	Co	Mo	Ti	Al	CT
A	0.003	0.02	0.003	0.007	0.005	17.90	7.75	2.96	0.20	-	-
B	0.005	0.03	0.005	0.008	0.02	18.40	8.50	3.34	0.20	0.07	-
C	0.02	0.07	0.001	0.009	0.08	17.78	7.07	4.46	0.185	-	-
D	0.034	0.124	0.014	0.014	0.124	18.4	7.58	3.258	0.285	0.14	0.54

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STEEL, 18 Ni Maraging: (250 Grade), DTD S212, G100, G110, Garval 18 (Sheet 1 of 3) Table 15

Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{3/2})	2.5 (K _{IC} σ _{ys}) ² in (mm)	Specimen			Ref.	
							Type	Thick- ness in (mm)	Width in (mm)		Crack Length in (mm)
250 Grade											
Plate: 1 in (25.4 mm) Thick	A,1	L-T	70(294)	259(1786)	68(74)	0.172(4.3)	Bend	0.250(6.4)	2.0 (50.8)	---	14
Rolled to 2 in (50.8 mm) thick- ness from Press Forged Slab	B,2	L-T	70(294)	227(1565)	96(105)	0.447(11.3)	Bend	1.8 (45.7)	3.75(95.3)	---	15
	B,2	L-T		232(1600)	85(93)	0.336(8.5)	Bend	1.8 (45.7)	3.75(95.3)	---	
	B,3	L-T		259(1786)	84(92)	0.263(6.7)	Bend	1.8 (45.7)	3.75(95.3)	---	
	B,4	L-T		259(1786)	80(87)	0.239(6.1)	Bend	1.8 (45.7)	3.75(95.3)	---	
Forging: 3 in (76.2 mm) Thick	C,5	T-L	70(294)	243(1675)	99(108)	0.415(10.5)	Bend 4 pt	0.480(12.2)	1.5 (38.1)	0.3 (7.6)	3
		T-L	-65(219)	---	90(98)	---	Bend 4 pt	0.480(12.2)	1.5 (38.1)	0.3 (7.6)	
Plate: 1 in (25.4 mm) Thick	D,6	-	70(294)	246(1696)	105(114)	0.455(11.6)	Bend	1.00 (25.4)	3.0 (76.2)	---	10
		-	0(255)	250(1724)	72(78)	0.207(5.3)	Bend	1.00 (25.4)	3.0 (76.2)	---	
		-	-100(200)	300(2068)	75(82)	0.156(4.0)	Bend	1.00 (25.4)	3.0 (76.2)	---	
		-	-200(144)	260(1834)	52(57)	0.100(2.5)	Bend	1.00 (25.4)	3.0 (76.2)	---	
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Vacuum Arc Remelt	E,7	L-T	-110(194)	273(1882)	86(94)	0.248(6.3)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	16
		T-L	-110(194)	272(1875)	80(87)	0.216(5.6)	SLN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	
		L-S	-110(194)	259(1786)	82(89)	0.251(6.4)	SEN	0.250(6.4)	1.0(25.4)	1.500(12.7)	16
		TL	-110(194)	260(1793)	80(87)	0.237(6.0)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
Forging: 13 x 13 in (330.2 x 330.2 mm) Vacuum Arc Remelted		S-T	-110(194)	262(1806)	82(89)	0.245(6.2)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
		ST4-ST4	-110(194)	262(1806)	72(78)	0.189(4.8)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	

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STEEL: 18 Ni Maraging (250 Grade), DTD 5212, G100, G110, Marval 18 (Sheet 2 of 3) Table 15 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (N/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 (K _{IC} σ _{ys}) ² in (mm)	Specimen			Ref.
							Type	Thickness in (mm)	Width in (mm)	
Plate: 1.5 x 23 in (38.1 x 330.2 mm)	F, 8	LS	-110(194)	262(1806)	83(90)	0.251(6.4)	SEN 0.250(6.4)	1.0(25.4)	0.500(12.7)	16
		TL	-110(194)	267(1841)	73(80)	0.187(4.7)	SEN 0.250(6.4)	1.0(25.4)	0.500(12.7)	
		ST	-110(194)	267(1841)	69(75)	0.167(4.2)	CT 0.500(12.7)	1.0(25.4)	0.500(12.7)	
		TL	-110(194)	264(1820)	84(92)	0.253(6.4)	SEN 0.250(6.4)	1.0(25.4)	0.500(12.7)	
<u>DTD 5212</u>										
Forged Plate: 2.5 in (63.5 mm) Thick	F, 8	L-T	70(294)	246(1696)	91(100)	0.542(8.7)	(a) ---	---	---	65
<u>G100</u>										
Forged Bar: 5 in (127 mm) Thick	H, 11	T-S	70(294)	204(1407)	88(97)	0.465 (11.8)	(a) ---	---	---	69
	H, 12	T-S	20(294)	225(1551)	82(90)	0.332 (8.4)	(a) ---	---	---	
	H, 13	T-S	70(294)	248(1706)	83(92)	0.280 (7.1)	(a) ---	---	---	
<u>G110</u>										
Bar: 4.9 in (125 mm) Thick, Vac. Melted	G, 9	L-ST	70(294)	*262(*1806)	92(101)	---	(a) ---	---	---	70
		ST-L	70(294)	*260(*1793)	85(93)	---	(a) ---	---	---	
Bar: 8 in (203) Sq Double Vac. Melted	G, 9	ST-L	70(294)	*265(1834)	82(90)	---	(a) ---	---	---	
Plate:	G, --	---	70(294)	235(1620)	80(88)	0.290 (7.4)	Bend 0.715(18.2)	1.0(25.4)	0.47(11.9)	57
<u>Marval 18</u>										
	--	T-S	70(294)	245(1689)	100(110)	0.416(10.6)	Bend 0.5 (12.7)	1.0 (25.4)	---	60

(a) Specimen in accordance with ASTM Recommendations

* tensile Ultimate Values

STEEL, 18 Ni Maraging. 300 Grade and G125

Table 16

Table 20 STEEL, 18 Ni Maraging. 300 Grade and G125															
Form	Composition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{3/2})	2.5 /K _{IC} ² (σ _{ys}) in (mm)	Specimen			Ref.					
							Thickness in (mm)	Width in (mm)	Crack Length in (mm)						
300 Grade															
Plate: 0.5 in (2.7 mm) Thick	A,1	T-L	600(589)	236(1627)	80(87)	0.287 (7.3)	CC	0.25 (6.4)	3.0 (76.2)	1.0 (25.4) 53					
		T-L	70(294)	280(1931)	68(74)	0.147 (3.7)	CC	0.25 (6.4)	3.0 (76.2)	1.0 (25.4)					
		T-L	-100(200)	305(2103)	42(46)	0.047 (1.2)	CC	0.25 (6.4)	3.0 (76.2)	1.0 (25.4)					
Plate: 1 in (25.4 mm) Thick	B,2	I-ST	70(294)	285(1965)	52(57)	0.083 (2.1)	Bend	0.25(6.4)	1.0 (25.4)	— 14					
Forging: 8 in (203) Dia Con. Elec. Vac. Remelt	C,3	I-T	70(2 94)	299(2062)	68(75)	0.129 (3.3)	Bend	0.5(12.7)	1.0 (25.4)	0.5 (12.7) 59					
		T-L	70(294)	300(2068)	68(75)	0.128 (3.3)	Bend	0.5(12.7)	1.0 (25.4)	0.5 (12.7)					
		T-L	-65(219)	---	54(59)	---	Bend	0.5(12.7)	1.0 (25.4)	0.5 (12.7)					
	D,3	I-T	70(294)	280(1931)	83(91)	0.326 (8.3)	Bend	0.5(12.5)	1.0 (25.4)	0.5 (12.7)					
		I-L	70(294)	280(1931)	77(85)	0.189 (4.8)	Bend	0.5(12.5)	1.0 (25.4)	0.5 (12.7)					
G125															
Plate: 0.75 in (19 mm) Thick	E,4	L-T	70(294)	*296(2020)*	63(69)	---	(a)	---	---	70					
		T-L	70(294)	*296(2020)*	60(66)	---	(a)	---	---	40					
COMPOSITION															
										* Tensile Ultimate Values					
A	C	Si	Mn	P	S	Ni	Mo	Cu	Zr	B	Ti	Al	Fe	N	V
	0.03	0.06	0.07	0.003	0.007	18.00	4.77	9.16	0.12	0.70	0.005	0.01	-	-	-
B	0.03	0.021	0.06	0.003	0.010	18.53	4.64	8.89	0.15	0.69	-	-	-	-	-
C	0.003	0.002	0.01	0.002	0.004	18.51	4.84	9.11	0.15	0.84	0.002	0.011	0.002	0.01	-
D	0.014	0.05	0.02	0.004	0.004	18.25	4.79	8.87	0.10	0.60	0.004	0.010	-	-	-
E	0.01N	0.05M	0.05H	0.005M	0.005N	18.5N	4.85N	9.0N	-	0.75N	-	-	-	-	0.10M
HEAT TREATMENT															
1. 1650F (1172K), 1 Hr, Air Cool; Age 850F (728K), 3 Hr															
2. 1500F (1089K), Age 900F (756K), 3 Hr															
3. Double Anneal, 1700F (1200K), 1 Hr, Fan Cool to 200F (367K), 1500F (1089K), 1 Hr, Fan Cool to 200F (367K), Age 900F (756K), 6 Hr															
4. 1507F (1093K), Air Cool; 895F (753K), 3 Hr, Air Cool															

COMPOSITION

	C	Mn	Si	P	S	Ni	Mo	Cu	Zr	Ti	B	Cu	V
A	0.03	0.06	0.07	0.003	0.007	18.00	4.77	9.16	0.12	0.70	0.005	0.01	-
B	0.03	0.021	0.06	0.003	0.010	18.53	4.64	8.89	0.15	0.69	-	-	-
C	0.003	0.002	0.01	0.002	0.004	18.51	4.84	9.11	0.15	0.84	0.002	0.011	-
D	0.014	0.05	0.02	0.004	0.004	18.25	4.79	8.87	0.10	0.60	0.004	0.010	-
E	0.01N	0.05N	0.05N	0.005N	0.005N	18.5N	4.85N	9.0N	-	0.75N	-	-	0.10N

* Tensile Ultimate Values

HEAT TREATMENT

1. 1650F (1172K), 1 hr, Air Cool; Age 850F (728K), 3 Hr
2. 1500F (1089K), Age 900F (756K), 3 Hr
3. Double Anneal, 1700F (1200K), 1 hr, Fan Cool to 200F (367K), 1500F (1089K), 1 hr, Fan Cool to 200F (367K), Aged 900F (756K), 6 Hr
4. 1507F (1093K), Air Cool; 895F (753K), 3 Hr, Air Cool

SH11, 18Ni; Maraging: 55% Grade

Table 17

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength K _{SI} (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 (K _{IC} ² / σ _{YS}) in (mm)	Specimen			Ref.	
							Type	Thickness in (mm)	Width in (mm)		Crack Length in (mm)
Billet: 4 in (102mm) Sq. Cons. Elec. Vac. Arcmelt	A, 1	S-T	70(294)	338(2330)	37(40)	0.030 (0.8)	Bend	0.394(10)	0.394 (10)	0.15 (3.8)	17
		S-L	70(294)	---	37(40)		Bend	0.394(10)	0.394 (10)	0.15 (3.6)	
		L-S	70(294)	334(2302)	36(39)	0.029 (0.7)	Bend	0.394(10)	0.394 (10)	0.15 (3.8)	
COMPOSITION											
	C	Mn	P	S	Ni	Mo	Co	Al	Ti	B	Zr
A	0.005 0.01	0.010	0.002	0.005	18.61	4.64	11.93	0.13	1.36	0.001	0.01
HEAT TREATMENT											
1. Double Anneal, 1700F (1200K), 1 Hr; 1500F (1089K), 1 Hr; Aged 900F (750K), 8 Hr											

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STAINLESS STEEL: 17-4 PH

Table 18

Form	Composition, Heat Treat- ment	Test Orienta- tion	σ_F (ksi)	Yield Strength KSI (MN/m ²)	Typical K_{IC} KSI√in (MN/m ^{3/2})	$2.5\left(\frac{K_{IC}}{\sigma}\right)^2$ in (mm)	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
Plate: 0.5 in (12.7 mm) Thick	B, 1	L-T	200 (367)	161 (1110)	81 (88)	0.633 (16.1)	Bend	0.510 (13)	1.0 (25.4)	---
	A, 1	L-T	70 (294)	168 (1158)	46 (50)	0.187 (4.7)	Bend	0.510 (13)	1.0 (25.4)	---
	A, 1	T-L	---	---	36 (40)	---	Bend	0.510 (13)	1.0 (25.4)	---
	B, 1	L-T	70 (294)	170 (1172)	37 (41)	0.118 (3.0)	Bend	0.510 (13)	1.0 (25.4)	---
	B, 1	T-L	70 (294)	---	40 (44)	---	Bend	0.510 (13)	1.0 (25.4)	---
	B, 1	L-T	-50 (228)	189 (1303)	28 (31)	0.055 (1.4)	Bend	0.510 (13)	1.0 (25.4)	---
	A, 1	L-T	-50 (228)	183 (1262)	29 (32)	0.063 (1.6)	Bend	0.510 (13)	1.0 (25.4)	---
	A, 1	L-T	-100 (200)	190 (1310)	23 (25)	0.037 (1.0)	Bend	0.510 (13)	1.0 (25.4)	---
	B, 1	L-T	-100 (200)	195 (1344)	27 (29)	0.048 (1.2)	Bend	0.510 (13)	1.0 (25.4)	---
	C, 1	L-T	70 (294)	209 (1441)	52 (57)	0.177 (4.5)	Bend	0.635 (16.0)	0.635 (15.1)	---
Bar: 1/2 in (12.7 mm) Thick	E, 3	L-R	70 (294)	186 (1292)	48 (53)	0.166 (4.2)	Bend	0.75 (19.1)	1.5 (38.1)	0.75 (19.1) 120
Bar: 3/32 in (83.3 mm) Thick Electroslag remelted	D, 2	L-R	70 (294)	168 (1158)	85 (93)	0.640 (16.3)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4) 116
COMPOSITION										
	C	Mn	P	S	Si	Cr	Ni	Cu	Ta	Ch
A	0.036	0.24	0.018	0.016	0.58	15.8	1.31	3.46	0.02	0.21
B	0.037	0.28	0.019	0.013	0.60	15.7	4.37	3.29	0.01	0.21
C	0.038	0.22	0.018	0.018	0.64	15.7	4.27	3.46	0.01	0.21
D	0.030	0.28	-	0.55	15.6	15.6	4.52	3.39	-	0.24
L	0.04	0.70	0.15	0.08	0.41	15.9	4.45	3.45	-	0.23
HEAT TREATMENT										
1. 1400F, (1033K) 1 1/2 Hr; Cool to 55F (286K), Age 900F (756K), 1 Hr										
2. 11975 Condition										
3. 900F (756K), 1 Hr, (11900 Condition)										

Table 19

STAINLESS STEEL. 17-7 PH

TABLE 19

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (*K)	Yield Strength KSI (N/mm ²)	Typical K _{IC} KSI√in (MN m ^{3/2})	2.5 /K _{IC} ² in (mm) (σ _{ys})	Specimen	Ref.			
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 0.5 in (12.7 mm) Thick											
	A, 1	L-T	75(297)	164(1131)	66(72)	0.405(10.3)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.374(9.5)	7
	A, 1	T-L	75(297)	153(1055)	64(70)	0.436(11.1)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.203(1.9)	
	B, 2	L-T	75(297)	183(1262)	63(69)	0.295(7.5)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.269(6.8)	
	C, 2	L-T	75(297)	176(1212)	67(74)	0.363(9.2)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.236(6.0)	
	A, 1	L-T	-50(228)	178(1227)	43(47)	0.146(3.7)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.260(6.6)	
	C, 1	L-T	-50(228)	155(1069)	51(56)	0.271(6.9)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.223(5.7)	
	D, 1	L-T	-50(228)	179(1254)	45(99)	0.159(4.0)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.252(6.4)	
	A, 1	L-T	-100(200)	180(1241)	43(47)	0.143(3.6)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.206(5.2)	
	C, 1	L-T	-100(200)	180(1241)	47(52)	0.170(4.3)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.211(5.4)	
	D, 1	L-T	-100(200)	190(1310)	45(49)	0.141(3.6)	Bend 4 pt	0.5 (12.7)	1.0 (25.4)	0.234(5.9)	
	E, 2	L-T	75(297)	164(1130)	56(61)	0.291(7.4)	Bend 4 pt	0.223(5.7)	1.0 (25.4)	0.246(6.2)	
	E, 2	L-T	-50(228)	164(1158)	38(42)	0.128(3.3)	Bend 4 pt	0.223(5.7)	1.0 (25.4)	0.242(6.1)	
	E, 2	L-T	-100(200)	175(1207)	32(35)	0.084(2.1)	Bend 4 pt	0.223(5.7)	1.0 (25.4)	0.252(6.4)	
	F, 2	L-T	-100(200)	186(1283)	47(52)	0.159(4.0)	Bend 4 pt	0.197(5.0)	0.910(23.1)	0.263(6.7)	
	G, 2	L-T	-100(200)	168(1158)	49(54)	0.212(5.4)	Bend 4 pt	0.202(5.1)	0.930(23.6)	0.216(5.5)	
	H, 2	L-T	75(297)	206(1420)	69(76)	0.292(7.5)	Bend 4 pt	0.610(15.5)	0.616(16.6)	0.153(6.0)	

Plate: 0.188 in 4.8 mm Thick

Bar: 1 in (25.4 mm) Thick

COMPOSITION

	C	Cr	Ni	Al	Nb	Si	P	S
A	0.080	16.9	6.85	1.30	0.75	0.26	0.011	0.013
B	0.080	16.9	7.85	1.30	0.75	0.26	0.011	0.013
C	0.078	16.9	7.38	1.36	0.62	0.25	0.023	0.008
D	0.076	17.0	7.17	1.22	0.66	0.32	0.019	0.007
E	0.073	16.7	7.20	1.05	0.72	0.43	0.028	0.005
F	0.069	17.2	7.29	1.08	0.63	0.36	0.017	0.012
G	0.077	16.7	6.56	1.11	0.78	0.50	0.032	0.013
H	0.072	17.3	7.10	0.90	0.68	0.54	0.028	0.005

HEAT TREATMENT

1. 1400F (1035K), 1.5 hr; Cool to 550F (561K); Age 1050F (832K), 1.5 hr
2. 1750F (1228K), 10 min; Cool to -110F (194K), 3 hr; Age 950F (783K), 1 hr

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HEAT TREATMENT

1. 1400F (1035K), 1.5 hr; Cool to 550F (564K); Age 1050F (832K), 1.5 hr
2. 1750F (1228K), 10 min; Cool to -110F (194K), 3 hr; Age 950F (783K), 1 hr

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Table 20

Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{3/2})	2.5 $\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen			Ref.	
							Type	Thickness in (mm)	Width in (mm)		Crack Length in (mm)
Plate: 0.5 in (12.7 mm) Thick	A,1	L-T	+200(367)	196(1551)	88(96)	0.504(12.8)	Bend 4 pt	0.520(13.2)	1.0(25.4)	0.300(7.6)	7
	B,1	L-T	+200(367)	191(1517)	65(71)	0.290(7.4)	Bend 4 pt	0.520(13.2)	1.0(25.4)	0.317(8.8)	
	A,1	L-T	70(294)	207(1427)	45(49)	0.118(3.0)	Bend 4 pt	0.520(13.2)	1.0(25.4)	0.257(6.5)	
	B,1	L-T	70(294)	205(1400)	50(55)	0.152(3.9)	Bend 4 pt	0.520(13.2)	1.0(25.4)	0.276(7.0)	
	A,2	L-T	70(294)	195(1344)	76(83)	0.569(14.4)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.238(6.0)	
	A,2	L-T	70(294)	183(1262)	74(81)	0.409(10.4)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.287(7.3)	
	A,2	L-T	-50(228)	203(1400)	53(58)	0.170(4.3)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.381(9.7)	
	A,1	L-T	-50(228)	218(1503)	28(31)	0.041(1.0)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.160(4.1)	
	B,2	L-T	-50(228)	184(1250)	46(50)	0.625(15.9)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.269(6.8)	
	B,1	L-T	-100(200)	232(1630)	29(32)	0.039(1.0)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.300(7.6)	
	B,2	L-T	-100(200)	205(1400)	46(50)	0.13 (3.3)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.282(7.2)	
	A,2	L-T	-100(200)	200(1379)	47(51)	0.138(3.5)	Bend 4 pt	0.510(13.0)	1.0(25.4)	0.281(7.2)	
	C,3	L-T	-75(297)	173(1193)	53(58)	0.236(6.0)	Bend 4 pt	0.750(19.1)	0.750(19.1)	0.3 (7.6)	
	D,3	L-T	75(297)	178(1228)	50(55)	0.197(5.0)	Bend 4 pt	0.750(19.1)	0.750(19.1)	0.236(6.0)	
Bar: 1 in (25.4 mm) Thick											

Bar: 1 in (25.4 mm) Thick

COMPOSITION:

	C	Cr	Ni	Mo	Al	Mn	Si	P	S
A	0.070	15.3	7.71	2.30	1.28	0.61	0.60	0.012	0.009
B	0.070	15.1	7.31	2.37	1.19	0.52	0.26	0.018	0.012
C	0.055	14.5	7.33	2.16	1.15	0.75	0.39	0.018	0.016
D	0.060	14.6	7.43	2.21	1.22	0.74	0.38	0.019	0.013

HEAT TREATMENT:

1. 1400F (1033K) 1.5 Hr; Cool to 55F (286K); Age to 1650F (899K), 1 Hr
2. 1400F (1033K) 1.5 Hr; Cool to 55F (286K); Age to 1130F (616K), 1.5 Hr
3. 1400F (1033K) 1.5 Hr; Cool to 55F (286K); Age to 1080F (594K), 1.5 Hr

Table 21

STAINLESS STEEL: PH13-8 MO and PV 520R

STEELINLESS STEEL: PH13-8 MO and PV 520R

Table 21

Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{3/2})	2.5 (K _{IC} σ _{ys}) ² in (mm)	Specimen			Ref.	
							Type	Thickness in (mm)	Width in (mm)	Gage Length in (mm)	
PH13-8MO											
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Double Vacuum Melted	A,1	L-T	70(204)	206(1420)	92(100)	0.500(12.7)	DEC	0.500(12.7)	3.0(76.2)	0.500(12.7)	16
		L-T	-110(194)	229(1579)	43(47)	0.088(2.2)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
		T-L	-110(194)	227(1565)	41(45)	0.081(2.1)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
Forging: 15 x 15 in (380.2 x 380.2 mm)		L-T	-110(194)	224(1544)	53(58)	0.146(3.7)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
		T-L	-110(194)	218(1503)	57(62)	0.171(4.3)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
Plate: 1.5 x 15 in (38.1 x 380.2 mm)		L-T	-110(194)	219(1510)	47(51)	0.115(2.9)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
		T-L	-110(194)	226(1558)	47(51)	0.108(2.7)	SEN	0.250(6.4)	1.0(25.4)	0.500(12.7)	
Forging: 9 x 9 in (229 x 229 mm)	B,2	L-TS	70(294)	205(1412)	89(98)	0.468(11.9)	CN	1.0(25.4)	8.6(21.8)	---	50
		L-TS	-110(194)	219(1510)	42(46)	0.092(2.3)	CN	1.0(25.4)	8.6(21.8)	---	
PV520R											
Bar: 6 in (152 mm) Dia	C,2	L-R	70(294)	170(1172)	119(131)	1.225(31.1)	(a)	---	---	---	65

(a) Specimen in accordance with ASTM Recommendations

COMPOSITION

	C	Si	Mn	S	P	Mo	Ni	Cr	Al	Cu	N
A	0.942	0.02	0.02	0.001	0.003	2.06	8.07	12.58	1.11	-	-
B	0.015	0.32	0.10	0.003	0.003	2.14	8.40	12.72	0.96	-	-
C	0.070	0.69	1.60	0.020	0.020	0.050	5.48	13.75	-	1.60	0.350

PH 13-8MO

1. 1700 (1200) 1 Hr, Air Cool; Refrigerated at -110 (194), 16 Hrs; Aged 1000 (811), 1 Hr, Air Cool
2. 1920 (1350), 150 (110) 84H (723K), 3 Hr.

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(a) Specimen in accordance with ASTM Recommendations

COMPOSITION

	C	Si	Mn	S	P	Mo	Ni	Cr	Al	Cu
A	0.042	0.02	0.02	0.001	0.003	2.06	8.07	12.58	1.11	-
B	0.045	0.32	0.10	0.004	0.003	2.14	8.40	12.72	0.96	-
C	0.073	0.69	1.04	0.025	0.035	1.6N	5.4N	13.7N	-	1.6N 0.35N

PH 13-8MO

1. 1700F (927C) 1 Hr, Air Cool; Refrigerated at -110F (194K), 16 Hrs; Aged 1000F (538C), 1 Hr, Air Cool
2. 1921F (1052C), 150 x (112 x) 8411 (723K), 3 Hr.

STAINLESS STEEL: AISC 77, AISC 266 (Sheet 1 of 2)

Table 22

Form	Composition, Heat Treatment	Test Orientation	Temp (°F)	Yield Strength ksi (MN/m ²)	Typical K _{IC} ksi√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) in (mm)	Specimen			Crack Length in (mm)	Ref	
							Type	Thickness in (mm)	Width in (mm)			
AISC 77												
Plate: 0.5 in (12.7 mm) Thick	A,1	L-T	-50(228)	178(1227)	80(88)	0.505 (12.8)	Bend	0.775(19.7)	0.793(20.1)	0.22 (5.6)	7	
		L-T	-100(200)	180(1241)	54(59)	0.225 (5.7)	Bend	0.775(19.7)	0.793(20.1)	0.22 (5.6)		
		L-T	70(294)	201(1386)	74(81)	0.359 (8.6)	Bend	0.625(15.9)	1.0 (25.4)	---	50	
Forging: 9x9 in (230 x 230 mm)	B,3	L-T	70(294)	167(1151)	63(69)	0.356 (9.0)	CC	1.0 (25.4)	9.0 (229)	1.5 (38.1)		
		L-T	-110(193)	203(1400)	24(70)	0.35 (8.9)	CC	0.375(9.5)	6.0 (152)	0.5 (12.7)		
AISC 260												
Bar: 3 in (76.2 mm) Dia Air Melted	C,4	L-R	70(294)	222(1531)	74(81)	0.278 (7.1)	Bend	0.48 (12.2)	1.5 (38.1)	---	90	
		R-L	70(294)	210(1448)	50(76)	0.270 (6.9)	Bend	0.59 (1)	0.39 (1)			
	C,5	L-R	70(294)	277(1917)	106(117)	0.366 (9.3)	Bend	0.48 (12.2)	1.5 (38.1)			
Plate: 0.56 in (14.2 mm) Thick	C,6	L-T	70(294)	290(1379)	110(121)	0.75 (19.1)	Bend	0.5 (12.7)	1.5 (38.1)	0.5 (12.7)	77	
AISC 260												
Plate: 0.55 in (14 mm) Thick	D,7	L-T	75(297)	206(1420)	90(99)	0.477 (12.1)	Bend	0.5 (12.7)	1.5 (38.1)	---	114	
COMPOSITION												
	C	Si	Mn	S	P	Ni	Cr	Mo	V	Co	N	Cl
A	0.113	0.32	1.08	0.006	0.012	4.06	15.08	2.82	-	-	-	-
B	0.12	0.44	1.21	0.009	0.015	4.49	15.02	2.76	-	-	-	-
C	0.16	0.13	0.18	0.021	0.015	0.21	14.0	5.02	0.23	13.41	0.04	-
D	0.07	0.30	0.34	0.012	0.015	1.94	15.4	4.3	-	13.0	0.04	0.14
HEAT TREATMENT												
1.	1710F (1206K), Water Quench; -100F (200K), 3 hr; Age 1000F (811K), 3 hr											
2.	1710F (1206K), 10 min; Temper 925F (770K), 3 hr											
3.	1925F (1325K), 0.5 hr; Oil Quench; -100F (200K), 3 hr; Temper 850F (728K), 2 hr; Oil Quench; -100F (200K), 3 hr, 850F (728K), 1 hr, Air Cool											
4.	1900F (1311K), 1 hr, Oil Quench, -100F (200K), 0.5 hr; Temper 800F (700K), 2 hr + 2 hr, Air Cool											

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Table 22 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Temp, °F (°C)	Yield Strength KSI (N/mm ²)	Typical K_{IC} KSI√in (N/mm ^{3/2})	$2.5\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen			
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
HEAT TREATMENT										
5. 2000F (1067K), 1 hr, Oil Quench; -100F (200K), 0.5 hr; Temper 500F (533K), 2 hr, 10% Cold Reduction by Rolling; Temper 700F (644K), 2 hr + 2 hr, Air Cool										
6. Cold Rolled from 1.12 in (28.5 mm) Plate to 0.56 in (14.2 mm) in 5 stages with Intermediate Anneal, 1400F (1033K); 1800-1875F (1255-1297K), 1 hr, Oil Quench; -100F (200K), 0.5 hr, Temper 500F (533K), 2 hr + 2 hr										
7. 2000F (1067K), 1 hr; 1900F (1311K), 1 hr, Oil Quench; -320F (76K), 1 hr, 1000F (811K), 2 hr + 2 hr										

STELL: ABS-C, ASIN A203 Grade A & B

Table 23

Form	Compo- sition, Heat Treat- ment	Test Orien- tation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref	
							Type	Thickness in (mm)	Width in (mm)		Crack Length in (mm)
A85-C Plate: 1 in (25.4 mm) Thick. Open Heart Si-Al Killed											
	A,1	L-T	70(293)	39(269)						10	
		L-T	-210(138)	60(414)	43(47)	1.28 (32.6)	Bend	1.0 (25.4)	3.0 (76.2)		1.6 (40.6)
		L-T	-275(103)	94(648)	25(27)	0.177(4.5)	Bend	1.0 (25.4)	3.0 (76.2)		1.6 (40.6)
		L-T	-221(77.2)	116(809)	23(25)	0.098(2.5)	Bend	1.0 (25.4)	3.0 (76.2)		1.6 (40.6)
A203 Grade A Plate: 1.65 in (42 mm) Thick											
	B,2	L-T	-200(144)	65(448)	51(56)	1.54 (39.1)	CT	1.645(41.8)	---	102	
		L-T	-250(112)	77(531)	39(43)	0.641(16.3)	CT	1.645(41.8)	---		
		L-T	-250(112)	90(621)	57(62)	1.002(25.5)	CT	1.645(41.8)	---		
		L-T	-300(88)	---	41(45)	---	CT	1.645(41.8)	---		
A203 Grade B Plate: 2 in (50.8 mm) Thick											
	C,2	L-T	-150(172)	61(421)	38(42)	0.970(24.6)	CT	2.0 (50.8)	---	102	
		L-T	-250(144)	70(483)	37(41)	0.698(17.7)	CT	2.0 (50.8)	---		
		L-T	-300(88)	---	39(43)	---	CT	2.0 (50.8)	---		
		COMPOSITION									
	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al	
A	0.20	0.60	0.009	0.016	0.023	0.02	0.07	0.01	0.03	0.057	
B	0.14	0.51	0.014	0.022	0.18	2.55	-	-	-	-	
C	0.11	0.45	0.010	0.023	0.23	3.35	-	-	-	-	
HEAT TREATMENT											
1. 1650F (1172K), 1 Hr, Air Cool											
2. Normalized											
3. 1650F (1172K), 2 Hr, Water Spray Quenched; Tempered 1150F (894K), 2 Hr, Air Cool											

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STEEL: Low Strength: AISI 1015

Table 24

STEEL: LOW STRENGTH; ALSO LOW

Form	Composition, Heat Treatment	Test Orientation	Yield Strength σ_y (ksi)	Typical K_{IC} $\left(\frac{KSI\sqrt{in}}{\left(\frac{3}{2} \right)} \right)$	$2.5 \left(\frac{K_{IC}}{\sigma_y} \right)^2$ in (mm)	Specimen			Ref
						Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)

Plate: 4 in (101.6 mm) Thick	A, 1	L-T	39 (269)	46 (50)	3.5 (88.9)	NOL	4.0(101.6)	10.22(260)	4.08(104)	45
		L-T	40 (276)	46 (50)	3.7 (84.1)	NOL	4.0(101.6)	10.22(260)	4.08(104)	

COMPOSITION

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	V	Ti
A	0.52	0.83	0.006	0.028	0.25	0.12	<0.10	0.03	0.29	<0.01

HEAT TREATMENT

1. Normalized; Heated to 1700F (1200K), Air Cooled

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STEEL: ASTM A216

Table 25

Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (N/m ²)	Typical K _{IC} KSI√in (MPa/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
A216 WCC Grade Casting: 20" x 20 x 48 in (508 x 508 x 219 mm)											
	A, 1	-	-50(228)	55(379)	90(59)	6.694(170)	WOL	6 (152)	15.3 (389)	6.5 (165)	103
			-100(200)	61(421)	49(54)	1.613 (41)	WOL	2 (50.8)	5.1 (130)	2.08 (53)	
			-150(172)	67(462)	48(53)	1.283(32.6)	WOL	2 (50.8)	5.1 (130)	2.12 (54)	
			-200(144)	77(531)	33(36)	0.459(11.7)	WOL	2 (50.8)	5.1 (130)	2.11 (54)	
COMPOSITION											
	C	Mn	P	S	Si	Ni	Cr	Mo	Al		
A	0.24	1.15	0.008	0.011	0.44	0.37	0.09	0.02	0.06		
HEAT TREATMENT											
1. 1650F (1172K), 8 hr, Furnace Cool 600F (589K); 1125F (881K), Furnace Cool 650° (589K); 1750F (1228K), 8 hr, Furnace Cool to 1650F (1172K), Equalize; Accelerated Cooling to 200F (367K), Temper 1300F (922K), 8 hr, Air Cool											

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STILL: ASTH A302B

Table 26

Form	Composition, Heat Treatment	Test Orientation	Temp of Test, °K	Yield Strength, ksi (N/mm ²)	Typical K_{IC} $KSI\sqrt{in} \left(\frac{MN}{m^{\frac{3}{2}}} \right)$	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 1 in (25.4 mm) thick	A, 1	L-T	-150 (172)	65 (448)	47 (52)	1.31 (33.2)	Bend	1.0 (25.4)	3.0 (76.2)	1.6 (40.6)	10
		L-T	-200 (144)	73 (503)	32 (35)	0.48 (12.2)	Bend	1.0 (25.4)	3.0 (76.2)	1.6 (40.6)	
		L-T	-250 (112)	89 (614)	25 (27)	0.197 (5.0)	Bend	1.0 (25.4)	3.0 (76.2)	1.6 (40.6)	
		L-T	-321 (77)	123 (848)	23 (25)	0.087 (2.2)	Bend	1.0 (25.4)	3.0 (76.2)	1.6 (40.6)	
Plate: 7 in (178 mm) thick	B, 2	T-L	0 (256)	50 (345)	53 (58)	2.8 (71.3)	WOL	4.0 (101.6)	4.5 (114.3)	2.0 (50.8)	11
		T-L	-100 (200)	63 (434)	45 (49)	1.28 (32.4)	WOL	4.0 (101.6)	4.5 (114.3)	2.0 (50.8)	
		T-L	-200 (144)	85 (586)	34 (37)	0.40 (10.2)	WOL	2.0 (50.8)	2.25 (57.2)	1.0 (25.4)	
		T-L	-321 (77)	140 (965)	26 (28)	0.086 (2.2)	WOL	2.0 (50.8)	2.25 (57.2)	1.0 (25.4)	
	C, 3	L-T	-25 (235)	61 (421)	76 (83)	3.88 (98.6)	WOL	6.0 (152.5)	8.63 (219)	3.0 (76.2)	104
		L-T	-200 (100)	82 (565)	42 (46)	0.656 (16.7)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		L-T	-250 (112)	98 (676)	31 (34)	0.25 (6.4)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		L-T	-100 (200)	60 (414)	40 (44)	1.11 (28.2)	WOL	4.0 (101.6)	4.5 (114.3)	1.5 (38.1)	105
	D, 2	L-T	-200 (144)	80 (552)	30 (33)	0.35 (8.9)	WOL	2.0 (50.8)	2.25 (57.2)	0.75 (19.1)	
		L-T	-321 (77)	130 (896)	27 (30)	0.11 (2.7)	WOL	4.0 (101.6)	4.5 (114.3)	1.5 (38.1)	

COMPOSITION

	C	Mn	P	S	Si	Mo	Ni	Cr	Cu	Al
A	0.19	1.40	0.017	0.014	0.16	0.49	0.03	0.07	0.03	0.010
B	0.21	1.34	0.015	0.010	0.27	0.50	0.04	-	-	-
C	0.21	1.35	0.013	0.014	0.34	0.33	0.16	0.21	0.005	-
D	0.21	1.54	0.015	0.010	0.27	0.50	0.04	-	-	-

HEAT TREATMENT

- 1650F (1172K), 70 minutes, Air Cool
- Normalize 1650F (1172K), 7 hr, Fan Cool to 200F (367K), Air Cool; Stress Relieve
- 1200F (922K), 7 hr
- 1650F (1172K), 7 hr; Stress Relieve 1200F (922K), 7 hr; Fan Cool to 800F (700K), Air Cool

STEEL: Low Strength: ASTM A533 (Sheet 1 of 2)

Table 27

Form	Composition, Heat Treatment	Test Orientation	Yield Strength KSI (MN/m ²)	Typical K _{IC} (KSI√in) (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			
						Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
ASTM A533, Grade B, Class 1 Plate: 12 in (305 mm) Thick	A,1	L-T	70(483)	*140(153)	10 (254)	CT	12 (305)	24 (610)	12 (305)
		L-T	73(503)	*105(115)	5.17 (1.31)	CT	10 (254)	20 (508)	10 (254)
		L-T	75(517)	* 75(83)	2.5 (63.5)	CT	6 (152)	12 (305)	6 (152)
		L-T	77(531)	* 57(62)	1.37 (34.8)	CT	4 (102)	8 (203)	4 (102)
		L-T	79(545)	* 48(53)	0.92 (23.3)	CT	4 (102)	8 (203)	4 (102)
		L-T	86(593)	* 40(44)	0.54 (13.7)	CT	4 (102)	8 (203)	4 (102)
		L-T	95(655)	* 38(42)	0.40 (10.2)	CT	4 (102)	8 (203)	4 (102)
		L-T	111(765)	* 37(41)	0.38 (9.7)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	85(586)	33(36)	0.38 (9.7)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	93(641)	29(32)	0.24 (6.1)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
Plate: 11.75 in (298 mm) Thick	C,3	L-T	124(855)	26(28)	0.11 (2.8)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	77(531)	86(95)	3.12 (79.2)	CT	4 (102)	8 (203)	4 (102)
		L-T	82(565)	75(82)	2.09 (53.1)	CT	4 (102)	8 (203)	4 (102)
		L-T	85(586)	55(60)	1.05 (26.7)	CT	3 (76.2)	6 (152)	3 (76.2)
		L-T	95(655)	45(49)	0.56 (14.2)	CT	2 (50.8)	4 (102)	2 (50.8)
		L-T	143(986)	38(42)	0.18 (4.6)	CT	1 (25.4)	2 (50.8)	1 (25.4)
		L-T	71(490)	38(42)	0.716(18.2)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	102(702)	33(36)	0.262(6.6)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	129(889)	34(37)	0.174(4.4)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	71(490)	38(42)	0.716(18.2)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
Plate: 6 in (152 mm) Thick	B,2	L-T	102(702)	33(36)	0.262(6.6)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	129(889)	34(37)	0.174(4.4)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	71(490)	38(42)	0.716(18.2)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)
		L-T	102(702)	33(36)	0.262(6.6)	WOL	1 (25.4)	1.25(31.8)	0.5(12.7)

*Mild-Thickness Values

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(Table 27 (Cont.))

Form	Composition, Heat Treatment	Test Orientation	Temp, °F °C	Yield Strength KSI (N/m ²)	Typical K _{IC} KSI√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	

COMPOSITION

	C	Mn	P	S	Si	NI	Mo	Cr	Cu	Al
A	0.24	1.42	0.010	0.017	0.22	0.70	0.50	-	-	-
B	0.18	1.25	0.024	0.025	0.24	0.52	0.51	0.13	0.29	0.025
C	0.23	1.35	0.012	0.025	0.26	0.50	0.48	-	-	-

HEAT TREATMENT

1. Normalize 1675 ±25F (1186 ±14K); Austenitize 1600 ±500F (1144 ±28K), 4 Hr, Water Quench; Temper 1225 ±25F (936 ±14K), 4 Hr, Furnace Cool; Stress Relieve 1150 ±25F (894 ±14K), 40 Hr, Air Cool
2. Austenitize 1650F (1172K), 1 Hr; Temper 1200F (922K), 8 Hr; Stress Relieve 1100F (894K), 24 Hr.
3. Normalize 1675 ±25F (1186 ±14K); Austenitize 1600 ±50F (1144 ±28K), 4 Hr, Water Quench; Temper 1225 ±25F (936 ±14K), 4 Hr, Air Cool; Stress Relieve 1135 ±25F (886 ±14K), Hold 25 Hr, Furnace Cool to 600F (589K), Air Cool

Table 28

STEEL: Low Strength: ASTM A542 and ASTM A543

Form	Composition	Heat Treatment	σ_F (ksi)	Yield strength (ksi)	Typical K_{IC} (ksi \sqrt{in})	$2 \sqrt{\frac{a_{IC}}{b_{IC}}}$ (in)	Specimen		
							Thickness (in)	Width (in)	Crack Length (in)
ASTM A542 Plate: 6 in (152 mm) Thick	A, 1	L-T	-250 (144)	118 (814)	41 (35)	0.302 (7.7)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-250 (112)	132 (916)	55 (38)	0.176 (4.5)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-320 (76)	157 (1083)	29 (52)	0.08 (2.2)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
	A, 1	L-T	-250 (144)	113 (779)	69 (76)	0.932 (23.7)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-250 (112)	128 (893)	54 (38)	0.176 (4.5)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
ASTM A543 Plate: 6 in (152 mm) Thick	B, 2	L-T	-320 (78)	156 (1076)	30 (33)	0.092 (2.3)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-250 (112)	116 (800)	40 (44)	0.297 (7.5)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-320 (78)	141 (972)	30 (35)	0.113 (2.9)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
	B, 2	L-T	-200 (144)	110 (758)	75 (82)	1.16 (29.5)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-250 (112)	119 (821)	50 (55)	0.441 (11.2)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
ASTM A543 Plate: 12 in (305 mm) Thick	B, 2	L-T	-320 (78)	140 (965)	35 (39)	0.156 (4.0)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-250 (112)	119 (821)	50 (55)	0.441 (11.2)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-320 (78)	140 (965)	35 (39)	0.156 (4.0)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
	B, 2	L-T	-200 (144)	110 (758)	75 (82)	1.16 (29.5)	1 (25.4)	1.25 (31.8)	0.53 (13.5)
			-250 (112)	119 (821)	50 (55)	0.441 (11.2)	1 (25.4)	1.25 (31.8)	0.53 (13.5)

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
A	0.15	0.46	0.013	0.027	0.30	0.22	2.34	1.10	0.22	0.008
B	0.15	0.32	0.013	0.020	0.28	3.55	1.85	0.50	0.06	--

HEAT TREATMENT

1. 1750F (955C), 1 hr; 1200F (649C), 8 hr; 1100F (593C), 24 hr.
2. 1575F (858C), 1 hr; 1200F (649C), 8 hr; 1100F (593C), 24 hr.

STEEL: Intermediate Strength. ASTM A469 and NI-Mo-V Table 30

Form	Composition, Heat Treatment	Orientation	Temp. (°K)	Yield Strength ksi (N/mm ²)	Typical K _{IC} (ksi√in (MN/m ^{3/2}))	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
ASTM A469 Forging: 31 in (787 mm) Dia., 15 in (381 mm) Thick	A, 1	L-R	50 (283)	88 (607)	120 (131)	4.65 (118)	WOL	4 (102)	10.2 (259)	4 (102)
		L-R	0 (256)	90 (621)	70 (77)	1.51 (38.4)	WOL	2 (50.8)	5.1 (130)	2 (50.8)
		L-R	-100 (200)	95 (655)	35 (38)	0.339 (8.6)	CT	1 (25.4)	2 (50.8)	1 (25.4)
		L-R	-200 (144)	105 (724)	27 (30)	0.165 (4.2)	CT	1 (25.4)	2 (50.8)	1 (25.4)
		L-R	-320 (78)	150 (1034)	25 (27)	0.069 (1.8)	CT	1 (25.4)	2 (50.8)	1 (25.4)
NI-Mo-V Forging: 38 in (965 mm) Dia.	B, 2	C-R	150 (330)	80 (552)	70 (77)	1.914 (48.6)	WOL	4 (102)	10.2 (259)	3.6 (91.4)
		C-R	70 (294)	90 (621)	50 (50)	0.772 (19.6)	WOL	3 (76.2)	7.7 (196)	2.7 (68.6)
		C-R	0 (756)	95 (655)	40 (44)	0.443 (11.3)	WOL	2 (50.8)	5.1 (130)	1.8 (45.7)
		C-R	-100 (200)	100 (690)	30 (33)	0.225 (5.7)	WOL	2 (50.8)	5.1 (130)	1.8 (45.7)
		C-R	-200 (144)	110 (758)	25 (27)	0.129 (3.3)	WOL	1 (25.4)	2.6 (66)	0.9 (22.9)
		C-R	-320 (78)	140 (965)	23 (25)	0.067 (1.7)	WOL	1 (25.4)	2.6 (66)	0.9 (22.9)

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	V
A	0.20	0.55	0.010	0.009	0.19	2.96	0.48	0.29	0.08
B	0.23	0.50	0.005	0.010	0.21	3.4	0.48	0.30	0.07

HEAT TREATMENT

1. 1520F (1100K), 1180F (910K), 40 Hr.
2. 1475F (1075K), 20 Hr, Furnace Cool to 600F (588K), Hold 30 Hr; 1640F (1166K), 30 Hr, Air Cool to 530F (550K), Hold 30 Hr; Temper 1130F (883K), 40 Hr, Air Cool to 400F (478K), Air Cool

Table 31

STEEL: Intermediate Strength: ASTM A470 and CR-Mo-V

STEEL: Intermediate Strength: ASTM A470 and CR-MO-V										
Form	Composition, Heat Treatment	Test Orientation	Yield Strength ksi (N/mm ²)	Typical K _{IC} (ksi√in) (N/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref
						Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
ASTM A470 Forging: 15 in (381 mm) Dia.	A, 1	L-R	150(339)	84 (92)	2.48 (57.9)	WOL	4 (.02)	10.2(259)	4 (102)	108
		L-R	75(297)	50 (55)	0.723(18.4)	WOL	4 (102)	10.2(259)	4 (102)	
		L-R	0(256)	40 ()	0.443(11.3)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
		L-R	-100(200)	30 (33)	0.204(5.2)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
		L-R	-200(144)	25 (27)	0.109(2.8)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
		L-R	-320(78)	23 (25)	0.052(1.3)	WOL	1 (25.4)	2.55(64.8)	1 (25.4)	
CR-MO-V Hot Forging	B, - C, -	L-R	70(294)	69 (76)	1.738(44.1)	Bend	4 (102)	4 (102)	1 (25.4)	109
		L-R	70(294)	65 (71)	1.650(41.9)	Bend	6.7(170)	6.7(170)	1.6(40.6)	

COMPOSITION

	C	Mn	P	S	Si	Ni	Cr	Mo	V
A	0.31	0.78	0.009	0.010	0.28	0.07	1.10	1.15	6.26
B	0.3	-	-	-	-	0.7	1.0	0.7	0.32
C	0.3	-	-	-	-	0.6	1.2	1.1	0.37

HEAT TREATMENT

1. 175F (1242K), 1240F (944K), 40 Hr.

STEEL: Intermediate Strength: ASTM A471 and Ni-Cr-Mo-V

[illegible]

Table 33
SHELL: Intermediate Strength: ASTM A517-F and HY130

Form	Composition, Heat-treated	Yield strength f_{y1} (ksi/mm ²)	Typical K_{IC} $ASVTn$ (ksi√in (MPa/m ^{1/2}))	$\Delta S(\frac{K_{IC}}{\sigma})$ in (mm)	Specimen			Ref			
					Thickness in (mm)	Width in (mm)	Crack Length in (mm)				
ASTM A517-F											
Plate: 1 in (25.4 mm) Thick, Open Hearth Melted											
	A, 1	1-1	-100 (200)	75 (82)	1 (25.4)	3 (76.2)	1.6 (40.1)	10			
		1-1	-165 (16.2)	53 (55)	1 (25.4)	3 (76.2)	1.6 (40.1)				
		1-1	-200 (111)	47 (51)	1 (25.4)	3 (76.2)	1.6 (40.1)				
		1-1	-320 (78)	35 (38)	1 (25.4)	3 (76.2)	1.6 (40.1)				
HY130											
Plate: 1 in (25.4 mm) Thick, Air Melted											
	B, 2	1-1	-250 (112)	80 (88)	1 (25.4)	3 (76.2)	1.6 (40.1)	10			
		1-1	-320 (78)	13 (17)	1 (25.4)	3 (76.2)	1.6 (40.1)				
COMPOSITION											
		C	Mn	P	S	Si	Ni	Cr	Mo	V	Al
A		0.17	0.78	0.012	0.017	0.23	0.88	0.56	0.42	0.036	0.26
B		0.11	0.85	0.009	0.007	0.25	1.91	0.58	0.58	0.06	0.021
HEAT TREATMENT											
1. 1660f (1178K), 70 minutes, water quench; 1230f (939K), 97 minutes, water quench.											
2. 1500f (1089K), 95 minutes, water quench; 1163f (890K), 93 minutes, water quench.											

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Table 34

TITANIUM, α Alloy: SAI-2.5 Sn

Form	Composition, Heat Treatment	Test Orientation	Temp σ_F ($^{\circ}$ F)	Yield Strength, KSI (MN/m^2)	Typical r_{IC} KSI/in (MN/m^2)	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen			Ref.
							Type	Thickness in (in)	Width in (mm)	Crack Length in (mm)
Plate: 0.5 in (12.7 mm) Thick (ELI)	A,1	L-T	-320(78)	175(1237)	65(71)	0.345(8.8)	Bend	0.250(6.4)	0.500(12.7)	---
		T-L	-320(78)	171(1179)	50(55)	0.214(5.43)	Bend	0.250(6.4)	0.500(12.7)	---
		L-T	-423(21)	205(1413)	55(60)	0.180(4.6)	Bend	0.250(6.4)	0.500(12.7)	---
		T-L	-423(21)	209(1441)	52(57)	0.155(3.9)	Bend	0.250(6.4)	0.500(12.7)	---
		L-T	-320(78)	203(1400)	26(28)	0.041(1.0)	Bend	0.250(6.4)	0.500(12.7)	---
Plate: 0.5 in (12.7 mm) Thick (Commercial Grade)	B,1	T-L	-320(78)	204(1407)	50(55)	0.150(3.8)	Bend	0.250(6.4)	0.500(12.7)	---
		L-T	-423(21)	233(1606)	25(27)	0.029(0.7)	Bend	0.250(6.4)	0.500(12.7)	---
		T-L	-320(78)	175(1193)	62(68)	0.321(8.2)	Bend	0.400(10.2)	0.75 (19.0)	0.375(9.5)
Plate: 0.8 in (20.3 mm) Thick (ELI)	C,2	T-L	-423(21)	187(1289)	65(61)	0.302(7.7)	Bend	0.400(10.2)	0.75 (19.0)	0.375(9.5)

COMPOSITION

	Al	Sn	Fe	N	C	Mn	Mg	U	O	N
A	5.0	2.6	0.16	0.01	0.023	0.006	---	0.001	9.086	0.010
B	5.1	2.3	0.34	0.015	0.023	0.006	---	0.017	---	0.015
C	5.1	2.50	0.19	---	0.02	---	0.01	94ppm	940ppm	70ppm

HEAT TREATMENT

1. 1500F (1089°C) Furnace Cooled
2. 1500F (1117K), 16 Hr, Furnace Cooled

TITANIUM, Near α Alloys: IMI 679, IMI 685, 8Al-1Mo-1V, 6Al-2Sn-4Zr-2Ti (Sheet 1 of 2) Table 35

Form	Composition, Treatment	Test Orientation	σ_F (°K)	Yield Strength KSI (N/mm ²)	Typical K_{IC} KSI/in (MN/m ^{3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_F} \right)^2$ in (mm)	Specimen				
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	Ref
IMI 679 Forging: 0.625 in (15.9 mm) Thick 8 Processed 2100F (1422K)	A,1	(a)	70(294)	141(979)	31(34)	0.119(3.0)	Bend	0.5(12.7)	---	---	22
Forging: 0.625 in (15.9 mm) Thick a + b Processed 1675F (1186 K)	A,1	(a)	70(294)	153(1055)	26(28)	0.072(1.8)	Bend	0.5(12.7)	---	---	
Forging: 1.25 in (31.8 mm) Thick 8 Forged 1800F (1255K)	E,5	(a)	70(297)	135(931)	57(62)	0.445(11.3)	Bend	0.5(12.7)	---	---	92
IMI 685 Bar: 1.75 in (45 mm) Dia. 8 Worked	E,6	L-C	70(294)	137(941)	64(70)	0.546(13.9)	(b)	---	---	---	121
Plate: 0.7 in (18 mm) Thick, a + b Worked	E,7	L-C	70(294)	143(884)	55(66)	0.370(9.4)	(b)	---	---	---	
	E,8	L-T	70(294)	130(896)	56(61)	0.464(11.8)	(b)	---	---	---	
6Al-2Sn-4Zr-2Ti Plate: 1.5 in (38.1 mm) Thick 1800F (1422K)	E,2	L-T	70(294)	138(951)	67(74)	0.589(15.0)	SEN	0.87(22.1)	5 (127)	1.7(43.2)	82
Forging: 0.625 in (15.9 mm) Thick 8 Processed 2100F (1422K)	C,3	(a)	70(294)	126(868)	57(63)	0.512(13.0)	Bend	0.5(12.7)	---	---	22
Forging: 0.625 in (15.9 mm) Thick a + b Processed 1800F (1255K)	C,3	(a)	70(294)	145(986)	34(37)	0.167(4.3)	Bend	0.5(12.7)	---	---	
6Al-2Sn-4Zr-2Ti Forging: 0.625 in (15.9 mm) Thick 8 Processed 2100F (1422K)	D,4	(a)	70(294)	146(1006)	52(57)	0.37(8.1)	Bend	0.5(12.7)	---	---	22
Forging: 0.625 in (15.9 mm) Thick c + b Processed 1750F (1228K)	D,4	(a)	70(294)	160(1103)	32(35)	0.100(2.5)	Bend	0.5(12.7)	---	---	

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TITANIUM, Near α Alloys: IMI 679, 1% 685, 8Al-1Mo-1V, 6Al-2Sn-4Zr-2Nb (Sheet 2 of 2) Table 35 (Cont.)

Form	Composition, Heat Treatment					Test Orientation	Temp °F (°C)	Yield Strength KSI (N/m ²)	Typical K_{IC} KSI√in (MN/m ^{3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen			Ref	
	Al	Mo	V	Sn	Zr						Fe	Si	C		N
COMPOSITION															
A	2.3	0.9	-	11.1	5.0	0.06	0.21	0.023	-	-	-	-	-	-	-
B	7.96	0.92	1.0	0.15	-	0.12	0	0.049	0.07	0.013	0.006	-	-	-	-
C	7.7	1.1	1.0	-	-	0.07	-	0.022	-	-	-	-	-	-	-
D	5.0	2.0	-	2.1	3.9	0.06	-	0.024	-	-	-	-	-	-	-
E	6.06	0.5	-	-	-	-	0.18	-	0.15	-	0.005	-	-	-	-
F	2.25N	1.0N	-	11.0N	5.0N	0.12M	0.12N	0.04M	0.10N	-	-	-	-	-	-
HEAT TREATMENT															
1.	1650F (1172K), Water Quench, 930F (772K), 24 hr, Air Cool														
2.	1803F (1255K), 1 hr, Water Quench; 1100F (867K), 2 hr, Air Cool														
3.	1850F (1283K), 1 hr, Water Quench; 1100F (867K), 8 hr, Air Cool														
4.	1775F (1242K), 1 hr, Water Quench; Aged 1100F (867K), 8 hr, Air Cool														
5.	1695F (1198K), 1 hr, Air Cool; 930F (772K), 24 hr, Air Cool														
6.	1291F (973K), Air Cool														
7.	1921F (1223K), Oil Quench; 1021F (823K), 24 hr														
8.	1831F (1273K), Air Cool; 931F (773K), 24 hr														

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TITANIUM: 3-B Alloys: INI 550, 6Al-2Mo (Sheet 1 of 2) Table 36

Form	Composition, Heat Treatment	Test Orientation	Temp. of Test (°K)	Yield Strength KSI (N/mm ²)	Typical K_{IC} KSI√in (MN/m ^{3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen			Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
INI 550 Plate: 0.63 in (16 mm) Thick Plate: 1.25 in (31.8 mm) Thick Plate: 2.13 in (54 mm) Thick Bar: 3.37 x 0.625 in (85.7 x 15.9 mm) Bar: 2 x 3.5 in (50.8 x 88.9 mm)	A,1	T-L	70(294)	160(1103)	74(81)	0.535(13.6)	Bend 4 pt	0.5(12.7)	1.5(38.1)	---
	A,2	T-L	70(294)	177(1220)	49(54)	0.192(4.9)	Bend 4 pt	0.5(12.7)	1.5(38.1)	---
	B,3	L-T	70(294)	142(978)	77(85)	0.735(18.7)	(a)	---	---	---
	C,4	L-T	70(294)	170(1174)	59(65)	0.301(7.6)	(a)	---	---	---
	D,5	L-T	70(294)	137(946)	61(67)	0.490(12.6)	(a)	---	---	---
	D,5	T-L	70(294)	135(931)	60(65)	0.494(12.5)	(a)	---	---	---
	D,6	T-L	70(294)	135(931)	59(64)	0.494(12.5)	(a)	---	---	---
	E,7	L-S	70(294)	137(945)	52(57)	0.360(9.1)	(a)	---	---	---
		T-L	70(294)	150(1034)	34(37)	0.126(3.3)	(a)	---	---	---
		T-S	70(294)	150(1034)	44(49)	0.215(5.5)	(a)	---	---	---
Forging: 5 x 1.48 in (127 x 36 mm) Thick Forging: 5.1 in (130 mm) Square Extrusion INI 551 Bar: 1 in (25.4 mm) Square Extrusion	F,8	L-T	70(294)	136(938)	48(53)	0.311(7.9)	(a)	---	---	---
	K,-	S,T-L	70(294)	136(938)	62(68)	0.520(13.2)	Bend	0.5(12.7)	1 (25.4)	0.54(13.8)
	K,-	S,T-S,T	70(294)	136(938)	48(53)	0.311(7.9)	Bend	0.5(12.7)	1 (25.4)	0.51(13)
	G,7	-	70(294)	137(945)	53(58)	0.374(9.5)	(a)	---	---	---
	H,7	L-T,S	70(294)	173(1195)	31(34)	0.080(2.0)	(a)	---	---	---
	I,7	L-R	70(294)	166(1143)	40(44)	0.145(3.7)	(a)	---	---	---
	I,9	L-R	70(294)	158(1086)	51(56)	0.260(6.6)	(a)	---	---	---
	J,10	T-L	70(294)	113(779)	100(110)	1.958(49.7)	Bend	3 (76.1)	6 (152)	3 (76.1)

(a) Specimen in Accordance with ASTM Recommendations

TITANIUM: α - β Alloys: IMI 550, IMI 551, 6Al-2V (Sheet 2 of 2) Table 36 (Cont.)

Form	Composition, Heat Treatment					Test Orientation	σ_T (ksi)	Yield Strength ksi (N/mm ²)	Typical K _{IC} ksi√in (MN/m ^{3/2})	$2.5\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen			Ref					
	Al	Mo	Sn	Fe	Si						C	H	O		N	Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)
COMPOSITION																			
A	4.0	4.3	2.1	0.09	0.50	-	0.005	-	-	-	-	-	-	-	-	-			
B	4.125	4.08	2.04	-	0.47	-	0.002	0.185	-	-	-	-	-	-	-	-			
C	4.08	3.99	2.10	-	0.48	-	0.001	0.19	-	-	-	-	-	-	-	-			
D	4.0	3.95	2.19	0.12	0.54	-	0.003	-	-	-	-	-	-	-	-	-			
E	4.0	4.0	2.08	0.29	0.48	-	0.159	-	-	-	-	-	-	-	-	-			
F	4.02	4.03	2.10	-	0.46	-	0.002	0.14	-	-	-	-	-	-	-	-			
G	4.11	3.95	2.00	-	0.53	-	0.003	0.2	-	-	-	-	-	-	-	-			
H	3.93	4.02	4.10	-	0.48	-	0.004	0.19	-	-	-	-	-	-	-	-			
I	4.08	3.89	3.97	-	0.55	-	0.001	0.2	-	-	-	-	-	-	-	-			
J	6.2	2.0	-	0.4	-	0.25	-	0.06	-	0.006	-	-	-	-	-	-			
K	4.01	3.95	2.09	0.04	0.51	-	0.003	-	-	-	-	-	-	-	-	-			
HEAT TREATMENT																			
1.	1650F (1173K), 0.5 hr, Air Cool; 800F (700K), 24 hr, Air Cool; 932F (773K), 24 hr, Air Cool																		
2.	1650F (1173K), 0.5 hr, Air Cool; Cold Rolled 20% Reduction; 932F (773K), 24 hr, Air Cool																		
3.	1760F (1248K), 1 hr, Water Quench; 1650F (1173K), 4 hr, Air Cool; 931F (773K), 24 hr, Air Cool																		
4.	1650F (1173K), 2 hr, Air Cool; 931F (773K), 24 hr																		
5.	1795F (1253K), 1 hr, Air Cool; 1650F (1173K), 1 hr, Air Cool; 931F (773K), 24 hr																		
6.	1795F (1253K), 1 hr, Air Cool; 1597F (1143K), 1 hr, Air Cool; 931F (773K), 24 hr																		
7.	1650F (1173K), Air Cool; 931F (773K), 24 hr																		
8.	1650F (1173K), 6 hr, Air Cool; 931F (773K), 24 hr																		
9.	1957F (1243K), Air Cool; 1650F (1173K), Air Cool; 931F (773K), 24 hr																		
10.	1750F (1228K), 3 hr, Air Cool; 1100F (867K), 1 hr, Water Quench																		

ALUMINUM: 6061 Alloy: IMI 680

Table 37

Form	Composition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-3/2})	2.5 /K _{IC} (σ _{ys}) in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Bar: 2 x 1.3 in (50.8 x 33 mm)	A,1	L-T	70(294)	179(1234)	29(32)	0.066 (1.7)	(a)	---	---	---	65
Forging: 0.75 in (19mm) Thick Disc	A,2	---	70(294)	140(965)	59(65)	0.444 (11.3)	(a)	---	---	---	56
	A,3	---	70(294)	143(984)	50(55)	0.306 (7.8)	(a)	---	---	---	
	A,4	---	70(294)	159(1093)	40(46)	0.158 (4.0)	(a)	---	---	---	
	A,5	---	70(294)	163(1123)	32(35)	0.96 (2.4)	(a)	---	---	---	
	A,6	---	70(294)	171(1200)	19(21)	0.29 (0.76)	(a)	---	---	---	
Forging: 4 x 6.2 in (102 x 158 mm) Thick Forging:	A,7	---	70(294)	192(1321)	15(16.5)	0.15 (0.39)	(a)	---	---	---	
	A,8	L-T	70(294)	166(1145)	45(49)	0.184(4.7)	Bend	0.50(12.7)	1.5(38.1)	0.35(8.9)	31
	A,-	T-S	70(294)	138(951)	69(76)	0.625(4.7)	Bend	0.5(12.7)	1.0(25.4)	---	60
		T-S	70(294)	150(1034)	54(59)	0.333(8.5)	Bend	0.5(12.7)	1.0(25.4)	---	

(a) Specimen in accordance with ASTM Recommendations

COMPOSITION

	Al	Mg	Si	Fe	S	P
A	2.25N	4.0N	11.0N	0.2N	0.013N	

HEAT TREATMENT

1. 1471-1501F (1073-1123K); 931F (773K), 24 hr, Air Cool
2. Forged at 1831F (1273K); 1606F (1148K), Furnace Cool; 967F (793K), 24 hr, Air Cool
3. Forged at 1596F (1198K); 1606F (1148K), Furnace Cool; 967F (793K), 24 hr, Air Cool
4. Forged at 1831F (1273K); 1498F (1088K), Water Quench; 967F (793K), 24 hr, Air Cool
5. Forged at 1696F (1128K); 1498F (1088K), Water Quench; 967F (793K), 24 hr, Air Cool
6. Forged at 1606F (1148K); 1606F (1148K), Water Quench; 967F (793K), 24 hr, Air Cool
7. Forged at 1831F (1273K); 1606F (1148K), Water Quench; 967F (793K), 24 hr, Air Cool
8. 1490F (1083K), 1 hr, Water Quench; 930F (772K), 24 hr, Air Cool

Table 38

TITANIUM: α -B Alloys: 4Al-3Mo-IV, 7Al-2.5Mo, 7Al-4Mo

Form	Composition, Heat Treatment	Test Orientation	σ_{TS} , σ_{TS}	Yield Strength ksi: (N/mm^2)	Typical K_{IC} ($\text{ksi}\sqrt{\text{in}}$) ($\text{MN/m}^{3/2}$)	$2.5\left(\frac{K_{IC}}{\sigma_{YS}}\right)^2$ in (mm)	Specimen			Ref
							Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Ti-4Al-3Mo-IV Plate: 0.5 in (12.7 mm) Thick	A, 1	L-T	70 (294)	155 (1069)	72 (78)	0.539 (13.7)	Bend 0.5 (12.7)	1.5 (38.1)	0.5 (7.6)	34
	A, 2	L-T	70 (294)	161 (1110)	63 (69)	0.382 (9.5)	Bend 0.5 (12.7)	1.5 (38.1)	0.5 (7.6)	
	A, 3	T-L	70 (294)	175 (1207)	66 (72)	0.356 (9)	Bend 0.5 (12.7)	1.5 (38.1)	0.5 (7.6)	94
	B, 3	(a)	70 (294)	146 (1007)	49 (53)	0.282 (7.2)	Bend 0.5 (12.7)	---	---	22
Ti-7Al-2.5Mo Plate: 0.5 in (12.7 mm) Thick	E, 7	T-L	70 (294)	152 (1048)	52 (57)	0.293 (7.4)	Bend 0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	95
	E, 8	T-L	70 (294)	136 (938)	65 (71)	0.571 (14.5)	Bend 0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	
Ti-7Al-4Mo Plate: 0.5 in (12.7 mm) Thick	D, 6	T-L	70 (294)	145 (1006)	33 (36)	0.129 (3.3)	Bend 0.5 (12.7)	1.5 (38.1)	0.5 (7.6)	94
	C, 4	(a)	70 (294)	155 (1069)	41 (45)	0.175 (4.4)	Bend 0.5 (12.7)	---	---	22

(a) Test orientation is not specified, but loading and crack propagation directions are in a plane where maximum grain flow is approximately radially symmetric.

COMPOSITION

	Al	Mo	V	Fe	C	H	O	N
A	4.5	3.3	1.0	0.10	0.03	0.006	0.11	0.009
B	4.4	3.1	1.1	0.08	0.02	-	-	-
C	6.9	4.0	-	0.12	0.023	-	-	-
D	6.9	3.7	-	0.15	0.02	0.005	0.15	0.007
E	6.8	2.4	-	0.04	0.02	0.004	0.06	0.008

HEAT TREATMENT

- 1875F (1297K), 1 hr, Air Cool; 1725F (1214K), 1 hr, Water Quench; 1050F (839K), 8 hr, Air Cool
- 1800F (1255K), 1 hr, Water Quench; Aged 1100F (867K), 8 hr, Air Cooled
- 1725F (1214K), 1 hr, Water Quench; 1050F (839K), 4 hr, Air Cool
- 1750F (1228K), 1 hr, Water Quench; 1050F (839K), 4 hr, Air Cool
- 1875F (1297K), 1 hr, Water Quench; 1100F (867K), 8 hr, Air Cool
- Mill Annealed
- 1800F (1255K), 0.5 hr, Water Quench; 1100F (867K), 8 hr, Air Cool
- Mill Annealed; Hot Rolled 50% Reduction at 1750F (1228K)

Table 39

Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/in (MN m ^{-3/2})	2.5 (K _{IC} ² / σ _{ys}) in (mm)	Specimen				Ref.
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 0.5 in (12.7 mm) Thick (c Processed)	A,1	L-T	75(297)	148(1020)	46(50)	0.240(6.1)	Bend	1.0 (25.4)	1.0 (25.4)	0.290(7.4)	7
		T-L	75(297)	---	42(46)	---	Bend	1.0 (25.4)	1.0 (25.4)	0.3 (7.6)	
		L-T	-50(228)	---	46(50)	---	Bend	1.0 (25.4)	1.0 (25.4)	0.3 (7.6)	
		L-T	-100(200)	185(1276)	47(51)	0.161(4.1)	Bend	1.0 (25.4)	1.0 (25.4)	0.26 (6.6)	
		L-T	75(297)	148(1020)	48(52)	0.263(6.7)	Bend	1.0 (25.4)	1.0 (25.4)	0.303(7.7)	
Plate: 0.75 in (19.1 mm) Nominal Thickness	B,1	L-T	-50(228)	177(1220)	53(58)	0.224(5.7)	Bend	1.0 (25.4)	1.0 (25.4)	0.267(6.8)	
		L-T	-100(200)	173(1193)	54(59)	0.246(6.2)	Bend	1.0 (25.4)	1.0 (25.4)	0.208(5.3)	
		L-T	75(297)	133(916)	75(82)	0.792(20.1)	Bend	0.781(19.8)	1.5 (38.1)	0.3 (7.6)	20
		T-L	75(297)	150(1034)	45(49)	0.225(5.7)	Bend	0.9 (22.9)	1.8 (45.8)	0.45 (11.4)	4
		T-L	-321(78)	227(1565)	36(39)	0.063(1.6)	Bend	0.9 (22.9)	1.8 (45.8)	0.45 (11.4)	
Plate: 0.5 in (12.7 mm) Thick	E,3	L-T	70(294)	148(1034)	70(77)	0.56(14.2)	Bend	0.5 (12.7)	1.5 (38.1)	---	34
		(b)	75(297)	146(1007)	60(65)	0.422(10.7)	Bend	0.5 (12.7)	---	---	22
		(b)	75(297)	150(1034)	46(50)	0.235(6.0)	Bend	0.5 (12.7)	---	---	
		L-T	70(294)	150(1034)	61(66)	0.413(10.5)	Bend	0.55 (14)	1.02 (26)	0.55 (14)	23
		T-L	70(294)	148(1020)	55(60)	0.345(8.8)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
Forging: 1.0 in (25.4 mm) Thick	J,6	T-L	150(339)	127(875)	78(86)	0.942(23.9)	WOL	2.0 (50.8)	6.2 (15.8)	1.8 (4.6)	11
		L-T	75(297)	110(966)	81(89)	0.837(21.3)	WOL	2.0 (50.8)	2.25(57.2)	0.5 (12.7)	
		L-T	-75(214)	159(1097)	68(75)	0.457(11.6)	WOL	2.0 (50.8)	6.2 (15.8)	1.8 (4.6)	
		L-T	70(294)	128(883)	71.78	0.769(19.5)	(a)	---	---	---	63
		L-T	70(294)	140(968)	58(53)	0.429(10.9)	(a)	---	---	---	
Bar: 2 in (50.8 mm) Dia	J,5	T-S	70(294)	117(1011)	55(60)	0.350(8.9)	Bend	0.5 (12.7)	1.0 (25.4)	---	60

Table 39 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	σ_f (ksi)	Yield Strength KSI (N/m ²)	Typical K_{IC} KSI√in (MN/m ^{3/2})	$2.5 \left(\frac{K_{IC}}{\sigma_f} \right)^2$ in (mm)	Specimen				
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 3 in (76.1 mm) Thick	K,9	T-L	70(294)	122(841)	101(111)	1.717(43.5)	Bend	3.0 (76.1)	6.0(152.2)	3.0 (76.1)	81
	K,10	T-L	70(294)	113(779)	100(110)	1.958(49.7)	Bend	3.0 (76.1)	6.0(152.2)	3.0 (76.1)	
Extrusion: 8.75 in (222 mm) OD 3 in (76.2) Wall Extruded at 1750F (1228K)	L,11	C-R	70(294)	138(952)	58(64)	0.442(11.2)	CT	0.75(19.1)	1.5(38.1)	0.75(19.1)	117

(a) Specimen in accordance with ASTM Recommendations
(b) Test orientation is not specified but loading and crack propagation directions are in a plane where maximum grain flow; approximately radially symmetric.

COMPOSITION

	Al	V	Fe	C	Si	O	N	H
A	6.2	4.2	0.15	0.020	-	-	-	-
B	6.3	4.3	0.15	0.026	-	-	-	-
C	5.83	3.78	0.16	-	-	-	0.022	0.006
D	6.1	4.12	0.13	0.024	-	0.16	0.013	0.008
E	6.4	3.9	0.17	0.03	-	0.15	0.018	0.003
F	6.3	4.1	0.09	0.025	-	-	-	-
G	6.3	4.1	0.13	0.023	-	0.17	-	0.004
H	6.18	3.91	0.07	-	-	-	-	0.001
I	6.54	4.24	0.7	-	0.16	-	0.007	0.002
J	6.13	4.0	0.31	0.11	-	-	-	-
K	6.0	4.1	0.5	0.023	-	0.07	0.008	-
L	6.3	4.2	0.20	0.02	-	0.13	0.009	0.004

HEAT TREATMENT

- 1700F (1200K) Air Cool; Age 1000F (811K), 4 Hr
- 1750F (1228K) 1 Hr, Air Cool; Age 1000F (811K), 4 Hr
- 1850F (1283K) 30 Min, Water Quenched, Aged 1250F (950K) 4 Hr
- 1725F (1214K) 1 Hr, Water Quenched; Aged 1050F (839K) 4 Hr, Air Cool
- 1725F (1214K) 1 Hr, Water Quenched; Aged 1000F (811K) 4 Hr, Air Cool
- Solution Treated and Aged
- 1741F (1223K), 1 Hr, Air Cool; 1246F (948K), 1 Hr, Air Cool
- 1291F (973K), Air Cool
- 1750F (1228K), 3 Hr, Water Quenched; Age 1100F (867K), 4 Hr, Air Cool
- 1700F (1200K), 3 Hr, Air Cool; 1100F (867K), 4 Hr, Water Quench
- 1750F (1228K), 3 Hr, Water Quenched; 1000F (811K), 4 Hr, Air Cool

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TITANIUM, α - β Alloy: 6Al-6V-2Sn (Sheet 1 of 2)

Table 40

Form	Composition, Heat Treatment	Test Orientation	Yield Strength KSI (10 ³ lb/in ²)	Typical K _{IC} KSI√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref
						Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Plate: 1.0 in (25.4 mm) Thick	A,1	L-T	75(297)	33(36)	0.079(2.0)	SEN	1.0 (25.4)	5.0 (12.7)	1.6 (40.6)	24
	A,2	L-T	75(297)	60(65)	0.323(8.2)	SEN	1.0 (12.7)	5.0 (12.7)	1.6 (40.6)	
Plate: 1.0 in (25.4 mm) Thick ELI Grade	B,3	L-T	75(297)	30(33)	0.070(1.8)	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	25
	B,4	L-T	75(297)	34(37)	0.099(2.5)	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	
	B,4	L-S	75(297)	38(42)	---	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	
	B,4	L-T	-321(77)	23(25)	0.020(0.5)	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	
	B,4	L-S	-321(77)	25(27)	0.023(0.6)	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	
Bar: 4.5 in (114.3 mm) Dia. Commercial Grade	G,5	L-C	75(297)	31(34)	0.070(1.8)	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	
	G,5	L-C	-321(77)	23(25)	0.018(0.5)	Bend	0.250(12.7)	0.500(12.7)	0.200(5.1)	
Extrusion: 8.75 in (222 mm) OD 3 in (76.2 mm) Wall, Extruded at 1675F (1186K)	H,11	C-P	70(294)	69(76)	0.582(14.8)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	117
	I,12	C-R	70(294)	32(35)	0.071(1.8)	CT	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	
Forging: 0.625 in (15.8 mm) Thick 8 Processed 2100F (1422K)	C,3	(a)	75(297)	38(41)	0.125(3.2)	Bend	0.500(12.7)	---	---	22
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Vacuum Arc Remelt	D,5	L-T	75(297)	60(65)	0.405(10.3)	HTC	0.500(12.7)	3.0 (76.2)	1.0 (25.4)	26
Forging: 4.5 x 4.5 in (114.3 x 114.3 mm) Vacuum Arc Remelt	D,5	L-ST	-110(194)	56(61)	0.239(6.1)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	16
		ST-L	-110(194)	50(55)	0.180(4.6)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	
Plate: 1.5 in (38.1 mm) Thick	D,6	L-S	-110(194)	41(45)	0.110(2.8)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	
		L-T	-110(194)	32(35)	0.068(1.7)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	
		TS-TS	-110(194)	25(27)	0.043(1.1)	CT	0.500(12.7)	1.0 (25.4)	0.500(12.7)	
Plate: 0.5 in (12.7 mm) Thick	D,6	L-T	-110(194)	33(36)	0.063(1.6)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	
		T-L	-110(194)	30(33)	0.053(1.3)	SEN	0.250(6.4)	1.0 (25.4)	0.500(12.7)	

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TITANIUM, α - β Alloy: 6Al-6V-2Sn (Sheet 2 of 2)

Table 40 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Temp., °F (°C)	Yield Strength, ksi (N/mm ²)	Typical K _{IC} (ksi√in (N/mm ^{3/2}))	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref	
							Type	Thickness in (mm)	Width in (mm)		Crack Length in (mm)
Handforging: 1.0 in (22 mm) Thick	F, 7	L-T	75 (297)	180 (1241)	29 (32)	0.065 (1.7)	Bend	0.55 (14)	1.02 (26)	0.55 (14)	23
		T-L	75 (297)	186 (1282)	26 (28)	0.049 (1.2)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
8 Forged: 4.92 in (125 mm) Dia	E, 8	L-C	70 (294)	139 (958)	60 (65)	0.466 (11.8)	(b)	---	---	---	53
	E, 9	L-T	70 (294)	178 (1227)	32 (35)	0.08 (2.1)	(a)	---	---	---	
	E, 10	L-T	70 (294)	194 (1338)	27 (30)	0.056 (1.4)	(a)	---	---	---	
	F, -	T-S	70 (294)	163 (1124)	17 (51)	0.200 (5.1)	Bend	0.5 (12.7)	0.5 (12.7)	1.0 (25.4)	60

(a) Test orientation is not specified but the loading and crack propagation directions are in a plane where maximum grain flow is approximately radially symmetric.
(b) Specimen in accordance with ASTM Recommendations

COMPOSITION

	Al	V	Sn	Cu	Fe	Cu	O	N	P	in
A	5.5	5.5	2.0	0.024	0.69	0.73	0.08	0.010	0.003	-
B	5.35	5.34	1.96	0.015	0.59	0.65	0.081	0.018	0.006	-
C	5.4	5.3	2.0	0.022	0.63	0.6	-	-	-	-
D	5.5	5.4	1.9	0.025	0.65	0.64	0.12	0.012	0.005	-
E	5.4	5.4	2.0	-	0.53	-	0.015	0.004	0.002	-
F	5.5	5.5	2.0	0.051	0.68	0.68	0.29	0.04	0.015	-
G	5.64	5.32	2.26	0.021	0.59	0.56	0.172	0.007	0.016	-
H	5.9	5.5	2.0	0.02	0.81	0.78	0.16	0.015	0.005	-
I	6.0	5.9	2.0	0.12	0.99	0.97	0.07	0.010	0.004	0.02

HEAT TREATMENT

1. 1550F (1117K), 1 Hr, Water Quenched; Aged 900F (756K), 4 Hr, Air Cool
2. 1625F (1158K), 1 Hr, Water Quenched; Aged 1200F (822K), 2 Hr, Air Cool
3. 1600F (1144K), 1 Hr, Water Quenched; Aged 1050F (839K), 4 Hr, Air Cool
4. 1650F (1172K), 1 Hr, Water Quenched; Aged 1125F (881K), 4 Hr, Air Cool
5. 1650F (1172K), 1 Hr, Water Quenched; Aged 1050F (839K), 1 Hr, Air Cool
6. 1550F (1117K), 1/4 Hr, Water Quenched; Aged 1050F (839K), 4 Hr, Air Cool
7. Solution Annealed and Aged
8. 1400F (1033K), Air Cooled
9. 1561F (1123K), 1 Hr, Water Quench; 967F (793K), 4 Hr, Air Cool
10. 1741F (1223K), 1 Hr, Water Quench; 967F (793K), 4 Hr, Air Cool
11. 1600F (1144K), 3 Hr, Water Quench; 1300F (978K), 6 Hr, Air Cool
12. 1600F (1144K), 3 Hr, Water Quench; 1000F (811K), 1 Hr, Air Cool

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(a) Test orientation is not specified but the loading and crack propagation directions are in a plane where maximum grain flow is approximately radially symmetric.

(b) Specimen in accordance with ASTM recommendations

COMPOSITION

	Al	V	Sn	C	Fe	Cu	O	N	H	Zn
A	5.5	5.5	2.0	0.024	0.69	0.73	0.08	0.010	0.003	-
B	5.33	5.34	1.96	0.015	0.59	0.65	0.081	0.018	0.006	-
C	5.4	5.3	2.0	0.022	0.63	0.6	-	-	-	-
D	5.5	5.4	1.9	0.025	0.65	0.64	0.12	0.012	0.005	-
E	5.4	5.4	2.0	-	0.53	-	0.015	0.004	0.002	-
F	5.5	5.5	2.0	0.051	0.68	0.68	0.281	0.041	0.0154	-
G	5.64	5.32	2.26	0.021	0.59	0.56	0.172	0.007	0.016	-
H	5.9	5.5	2.0	0.02	0.84	0.78	0.16	0.015	0.005	-
I	6.0	5.9	2.0	0.12	0.99	0.97	0.07	0.010	0.004	0.02

HEAT TREATMENT

- 1550F (1117K), 1 hr, Water Quench; Aged 900F (756K), 4 hr, Air Cool
- 1625F (1158K), 1 hr, Water Quench; Aged 1200F (922K), 2 hr, Air Cool
- 1600F (1144K), 1 hr, Water Quench; Aged 1050F (839K), 4 hr, Air Cool
- 1650F (1172K), 1 hr, Water Quench; Aged 1125F (881K), 4 hr, Air Cool
- 1650F (1172K), 1 hr, Water Quench; Aged 1050F (839K), 1 hr, Air Cool
- 1550F (1117K), 1/4 hr, Water Quench; Aged 1050F (839K), 4 hr, Air Cool
- Solution Annealed and Aged
- 1400F (1033K), Air Cooled
- 1561F (1123K), 1 hr, Water Quench; 967F (793K), 4 hr, Air Cool
- 1741F (1223K), 1 hr, Water Quench; 967F (793K), 4 hr, Air Cool
- 1600F (1144K), 3 hr, Water Quench; 1300F (978K), 6 hr, Air Cool
- 1600F (1144K), 3 hr, Water Quench; 1000F (811K), 1 hr, Air Cool

TITANIUM, α - β Alloys: 6Al-6V-4Zr-4Mo, 6Al-25Sn-4Zr-6Mo and 6Al-25Sn-2Zr-2Mo-2Cr (Sheet 1 of 2) Table 41

Form	Composition, Heat Treatment	Test Orientation	σ_L , σ_T , σ_R	Yield Strength, ksi (N/mm ²)	Typical K_{IC} , ksi√in (MN/m ^{3/2})	$2.5\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
6Al-6V-4Zr-4Mo Die Forging: 3.5 in (88.9 mm) Thick, β Forged 1750F (1228K) $\alpha+\beta$ Forged 1575F (1130K)	A,1	C-R	70 (294)	157 (1082)	40 (44)	0.162 (4.1)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	96
							4 Pt				
	A,1	C-R	70 (294)	170 (1172)	51 (56)	0.225 (5.7)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	
							4 Pt				
Forging: 4.25 x 6 in (108 x 152 mm), $\alpha+\beta$ Forged 1575F (1130K)	A,1	L-T	70 (294)	160 (1103)	49 (54)	0.234 (5.9)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	
							4 Pt				
	P,2	L-T	70 (294)	151 (1041)	45 (49)	0.222 (5.6)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	31
							4 Pt				
6Al-25Sn-4Zr-6Mo Forging: 1.5 in (38.1 mm) Square β Forged 1800F (1255K), Water Quench	C,4	-	70 (294)	*180 (1241)	46 (50)	---	---	---	---	---	100
	C,4	-	70 (294)	*168 (1158)	60 (66)	---	---	---	---	---	
Forging: 2 in (50.8 mm) Thick β Forged 1800F (1255K), Water Quench	C,2	C-R	70 (294)	169 (1165)	22 (24)	0.042 (1.1)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	96
							4 Pt				
Forging: 4.5 x 6 in (108 x 152 mm) $\alpha+\beta$ Forged, 1650F (1172K) Max	C,2	L-T	70 (294)	174 (1200)	25 (27)	0.052 (1.3)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	31
							4 Pt				
6Al-25Sn-2Zr-2Mo-2Cr Bar: 4 in (101.6 mm) Dia	D,5	L	70 (294)	160 (1103)	62 (68)	0.376 (9.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	101
							CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	
Forging: 1 in (25.4 mm) Thick, $\alpha+\beta$ Forged	D,6	L-R	70 (294)	161 (1110)	58 (64)	0.324 (8.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	
							CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	
Forging: 1 in (25.4 mm) Thick, $\alpha+\beta$ Forged	D,7	-	70 (294)	158 (1089)	74 (81)	0.548 (13.9)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	
							CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	
Ultimate Strength Values	D,7	-	70 (294)	160 (1103)	60 (66)	0.340 (8.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.9)	

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TITANIUM, α - β ALLOYS: 6Al-6V-4Zr-4Nb, 6Al-25Sn-4Zr-6Nb and 6Al-25Sn-2Zr-2Nb-2Cr (Sheet 2 of 2) Table 41 (Cont.)

Form	Composition, Heat Treatment	Yield strength ksi (N/mm ²)	Typical K _{IC} KSI√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref
					Type	Thickness in (mm)	Width in (mm)	

COMPOSITION:

- HEAT TREATMENT
1. 1525F (1193K), 4 Hr, Air Cool; 950F (873K), 8 Hr, Air Cool
 2. 1600F (1144K), 1 Hr, Water Quench; 1100F (867K), 8 Hr, Air Cool
 3. 1600F (1144K), 1 Hr, Air Cool; 1100F (867K), 8 Hr, Air Cool
 4. 1675F (1186K), 1 Hr, Air Cool; 1100F (867K), 8 Hr, Air Cool
 5. 1745F (1225K), 1 Hr, Water Quench; 1000F (811K), 4 Hr, Air Cool
 6. 1745F (1225K), 1 Hr, Oil Quench; 1000F (811K), 4 Hr, Air Cool
 7. 1745F (1225K), 1 Hr, Air Cool; 1000F (811K), 4 Hr, Air Cool

TITANIUM, B Alloys: 13V-11Cr-3Al, 8Mo-6V-2Fe-3Al, 11.5Mo-6Zr-4.5Sn, 3Al-8V-6Cr-4Zr-4Mo (Sheet 1 of 2) Table 4:

Form	Corporation, Heat Treatment	Yield Strength F_y (ksi/mm ²)	Typical K_{Ic} $AS\sqrt{in}$ (ksi/mm ^{3/2})	$2.5\left(\frac{K_{Ic}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen			Crack Length: a_i (mm)	Ref	
					Type	Thickness in (mm)	Width in (mm)			
13V-11Cr-3Al(B120VCA) Bar: 1 in (25.4 mm) Dia	A, 1	L-SI	300 (422)	159 (1096)	39 (43)	NR	Do=.505 (12.8)	Di=.375 (9.5)	28	
	A, 1	L-SI	70 (294)	181 (1248)	32 (35)	NR	Do=.505 (12.8)	Di=.375 (9.5)		
		L-SI	45 (230)	200 (1379)	28 (31)	NR	Do=.505 (12.8)	Di=.375 (9.5)		
Forgin 9.625 in (15.9 mm) Thick C-8 Processed: 1675F (1186K)	B, 2	(a)	70 (294)	178 (1227)	43 (47)	Bend	0.500 (12.7)	---	22	
Forging: 0.625 in (15.9 mm) Thick B Processed: 2109F (1422K)	B, 2	(a)	70 (294)	176 (1213)	41 (45)	Bend	0.500 (12.7)	---		
Forging: 4 in (102 mm) Thick	A, 3	L-1	70 (294)	166 (1145)	24 (26)	Bend	0.500 (12.7)	1.5 (38.1)	0.35 (8.9)	31
8Mo-8V-2Fe-3Al Plate: 0.5 in (12.7 mm) Thick Forged at 1950F (1339K)	C, 4	L-1	70 (294)	195 (1345)	45 (49)	SEN	0.375 (9.5)	1.125 (28.6)	0.375 (9.5)	93
Plate: 2 in (50.8 mm) Thick Forged at 1950F (1339K)	D, 4	L-1	70 (294)	200 (1379)	49 (54)	SEN	0.375 (9.5)	1.125 (28.6)	0.375 (9.5)	
Closed die Forging: 0.5 in (12.7 mm) Thick	L, 5	L-1	70 (294)	181 (1248)	38 (41)	Bend	0.500 (12.7)	1.5 (38.1)	0.300 (7.6)	29
2.5 in (63.5 mm) Thick		L-1	70 (294)	178 (1227)	41 (45)	Bend	2.5 (63.5)	1.5 (38.1)	0.300 (7.6)	
Forged Bar: 3 in (76.2 mm) Square	F, 5	L-1	70 (294)	165 (1158)	52 (57)	Bend	(b)	---	---	30
Forging: 4 in (102 mm) Thick	F, 5	L-1	70 (294)	176 (1213)	65 (69)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	31
Extrusion: Cylinder 8.75 in (222 mm) OD 3 in (76.2 mm) Wall, Extruded at 1475F (1075K)	G, 6	C-R	70 (294)	179 (1234)	51 (56)	CF	0.75 (19.1)	1.5 (38.1)	0.75 (19.1)	117
11.5Mo-6Zr-4.5Sn (4111) Plate: 0.5 in (12.7 mm) Thick	H, 7	L-1	70 (294)	174 (1200)	61 (67)	Bend	0.5 (12.7)	1.5 (38.1)	---	32
Plate: 0.61 in (16.3 mm) Thick	I, 8	-	70 (294)	166 (1145)	51 (56)	Bend	0.525 (13.3)	1.5 (38.1)	---	93
	I, 9	-	70 (294)	150 (1034)	65 (71)	Bend	0.525 (13.3)	1.5 (38.1)	---	
	I, 10	-	70 (294)	148 (1020)	71 (78)	Bend	0.525 (13.3)	1.5 (38.1)	---	

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TITANIUM, 8 Alloys: 13V-11Cr-3Al, 8Mo-8V-2Fe-3Al, 11.5Mo-6Zr-4.1Sn, 3Al-8V-eCr-4Zr-4Mo (Sheet 2 of 2) Table 42 (Cont.)

Form	Composition, Heat Treatment	Test Orientation	Yield Strength ksi (N/mm ²)	Typical K _{IC} (ksi√in) (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_y}$) ² in (mm)	Specimen			Ref	
						Type	Thickness in (mm)	Width in (mm)		
Forging: 4 in (102 mm) Thick	I, 11	L-T	182(1255)	61(67)	0.280(7.1)	Bend	0.5 (12.7)	1.5 (38.1)	0.25 (8.9)	31
Extrusion: 0.97 in (24.6 mm) Dia	K, 12	L-R	233(1606)	25(27)	0.027(0.7)	Bend	0.394(1)	0.394(1)	---	113
Extrusion: 0.9 in (22.9 mm) Dia	K, 14	L-R	186(1282)	41(45)	0.121(3.1)	Bend	0.394(1)	0.394(1)	---	118
	K, 15	L-R	167(1151)	54(59)	0.261(6.6)	Bend	0.394(1)	0.394(1)	---	
3Al-8V-6Cr-4Zr-4Mo (8C)										
Forging: 4 in (102 mm) Thick	J, 13	L-T	158(1089)	53(58)	0.281(7.1)	Bend	0.5 (12.7)	1.5 (38.1)	0.35 (8.9)	31
Billet: 6 in (152 mm) Square	J, 13	L-T, ST	167(1151)	59(65)	0.312(7.9)	Bend	0.75(19.1)	1.5 (38.1)	0.78 (19.8)	119

COMPOSITION

V	Cr	Al	Fe	C	Mo	Zr	Sn	N	H
A	13N	11N	3N	-	0.05N	-	-	-	-
b	13.5	10.5	3.1	0.16	0.17	-	-	-	-
C	7.08	-	2.87	2.16	-	-	-	0.019	0.112
D	8.09	-	3.02	2.19	-	-	-	0.020	0.098
E	7.81	-	2.95	2.17	-	-	-	0.005	0.122
F	8N	-	3N	2N	0.05N	8N	-	0.088	0.146
G	8.0	-	2.3	1.8	0.022	8.2	-	0.018	0.015N
H	-	-	-	0.03	-	10.71	4.12	4.60	6.097
I	-	-	-	-	-	11.5	6	-	-
J	8N	6N	3.1	-	-	4N	4.6	-	-
K	-	-	-	0.11	244ppm	10.95	5.86	4.48	80ppm
									1515ppm
									55ppm

HEAT TREATMENT

1.	1425F (1047K), 0.25 hr; 900F (756K), 72 hr
2.	1350F (1006K), 2 hr, Air Cool; 1450F (1061K), 0.5 hr, Water Quench; 900F (756K), 20 hr, Air Cool
3.	1335F (997K), 1 hr, Air Cool; 1450F (1061K), 0.5 hr, Air Cool; 900F (756K), 15 hr, Air Cool
4.	1500F (1089K), 10 min, Air Cool; 200F (756K), 16 hr, Air Cool
5.	1475F (1075K), 1 hr, Water Quench; 1000F (538K), 8 hr, Air Cool
6.	1475F (1075K), 1.5 hr, Water Quench; 1000F (538K), 8 hr, Air Cool
7.	1350F (1006K), 15 min, Delay 15 sec, Water Quench; 950F (783K), 8 hr
8.	1600F (1144K), 1 hr, Water Quench; 900F (756K), 8 hr
9.	1500F (1089K), 1 hr, Water Quench; 550F (561K), 0.5 hr, Air Cool
10.	1600F (1144K), 1 hr, Water Quench; 900F (756K), 100 hr, Air Cool
11.	1325F (992K), 1 hr, Water Quench; 950F (783K), 8 hr, Air Cool
12.	Extruded at 1800F (1255K), Water Quench; Swaged 5% Reduction in Area; 900F (756K), 8 hr
13.	1500F (1089K), 0.25 hr, Air Cool; 1050F (839K), 12 hr, Air Cool
14.	Extruded at 1400F (1033K), Water Quench; Aged 900F (756K), 8 hr, Air Cool
15.	Extruded at 1900F (1255K), Air Cool; 1400F (1033K), 0.5 hr, Water Quench; 900F (756K), 8 hr, Air Cool

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Temper	Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/in (MN m ^{-3/2})	2.5 (K _{IC} /σ _{YS}) in (mm)	Specimen			
								Type	Thickness in (mm)	Wid'n in (mm)	Crack Length in (mm)
2014 T651	Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70 (294)	67 (462)	24 (26)	0.321 (8.2)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)
			T-L	70 (294)	66 (455)	21 (23)	0.253 (6.4)	(b)	1.0 (25.4)	2.0 (50.8)	1.9 (25.4)
		A, (a)	L-T	70 (294)	59 (407)	21 (23)	0.317 (8.1)	(b)	1.0 (25.4)	2.0 (50.8)	1.7 (25.4)
			T-L	70 (294)	58 (403)	21 (23)	0.328 (8.3)	(b)	1.0 (25.4)	2.0 (50.8)	1.6 (25.4)
	Plate: 5.0 in (127 mm) Thick	A, (a)	S-L	70 (294)	-	19 (21)	-	-	-	-	-
			T-L	-320 (78)	-	26 (28)	-	(b)	1.02 (25.9)	2.0 (50.8)	1.01 (25.6)
		A, (a)	T-S	70 (294)	63 (435)	24 (26)	0.31 (9.2)	(b)	-	-	-
			L-T	70 (294)	64 (441)	30 (33)	0.549 (13.9)	SEV	0.594 (15.1)	3.0 (38.1)	-
	T6510 Extrusion: 0.625 in (15.9 mm) Thick	A, (a)	T-L	70 (294)	62 (427)	25 (27)	0.406 (10.3)	SEV	0.312 (7.9)	1.940 (23.9)	-
			L-T	70 (294)	67 (462)	25 (27)	0.338 (8.8)	Bend	0.750 (19.1)	1.5 (38.1)	-
		B, 1	T-L	70 (294)	65 (448)	19 (21)	0.214 (5.4)	Bend	0.750 (19.1)	1.5 (38.1)	-
			L-T	70 (294)	63 (434)	34 (37)	0.728 (18.5)	Bend	1.50 (38.1)	3.0 (76.2)	-
2014 T652	Plate: 1.0 in (25.4 mm) Thick	A, (a)	T-L	70 (294)	59 (403)	23 (25)	0.380 (9.7)	Bend	1.50 (38.1)	3.0 (76.2)	-
			S-L	70 (294)	57 (393)	19 (21)	0.278 (7.1)	Bend	1.50 (38.1)	3.0 (76.2)	-
		B, 2	L-T	70 (294)	64 (442)	26 (28)	0.413 (10.5)	(b)	-	-	-
			T-L	70 (294)	59 (405)	24 (26)	0.414 (10.5)	(b)	-	-	-
	Plate: 5.0 in (127 mm) Thick	A, (a)	L-T	70 (294)	67 (462)	24 (26)	0.321 (8.2)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)
			T-L	70 (294)	66 (455)	21 (23)	0.253 (6.4)	(b)	1.0 (25.4)	2.0 (50.8)	1.9 (25.4)
		A, (a)	L-T	70 (294)	59 (407)	21 (23)	0.317 (8.1)	(b)	1.0 (25.4)	2.0 (50.8)	1.7 (25.4)
			T-L	70 (294)	58 (403)	21 (23)	0.328 (8.3)	(b)	1.0 (25.4)	2.0 (50.8)	1.6 (25.4)
	T6510 Extrusion: 0.625 in (15.9 mm) Thick	A, (a)	S-L	70 (294)	-	19 (21)	-	-	-	-	-
			T-L	-320 (78)	-	26 (28)	-	(b)	1.02 (25.9)	2.0 (50.8)	1.01 (25.6)
		A, (a)	T-S	70 (294)	63 (435)	24 (26)	0.31 (9.2)	(b)	-	-	-
			L-T	70 (294)	64 (441)	30 (33)	0.549 (13.9)	SEV	0.594 (15.1)	3.0 (38.1)	-
2014 T652	Plate: 1.0 in (25.4 mm) Thick	A, (a)	T-L	70 (294)	62 (427)	25 (27)	0.406 (10.3)	SEV	0.312 (7.9)	1.940 (23.9)	-
			L-T	70 (294)	67 (462)	25 (27)	0.338 (8.8)	Bend	0.750 (19.1)	1.5 (38.1)	-
		B, 1	T-L	70 (294)	65 (448)	19 (21)	0.214 (5.4)	Bend	0.750 (19.1)	1.5 (38.1)	-
			L-T	70 (294)	63 (434)	34 (37)	0.728 (18.5)	Bend	1.50 (38.1)	3.0 (76.2)	-
	Plate: 5.0 in (127 mm) Thick	A, (a)	T-L	70 (294)	59 (403)	23 (25)	0.380 (9.7)	Bend	1.50 (38.1)	3.0 (76.2)	-
			S-L	70 (294)	57 (393)	19 (21)	0.278 (7.1)	Bend	1.50 (38.1)	3.0 (76.2)	-
		B, 2	L-T	70 (294)	64 (442)	26 (28)	0.413 (10.5)	(b)	-	-	-
			T-L	70 (294)	59 (405)	24 (26)	0.414 (10.5)	(b)	-	-	-
	T6510 Extrusion: 0.625 in (15.9 mm) Thick	A, (a)	S-L	70 (294)	-	19 (21)	-	-	-	-	-
			T-L	-320 (78)	-	26 (28)	-	(b)	1.02 (25.9)	2.0 (50.8)	1.01 (25.6)
		A, (a)	T-S	70 (294)	63 (435)	24 (26)	0.31 (9.2)	(b)	-	-	-
			L-T	70 (294)	64 (441)	30 (33)	0.549 (13.9)	SEV	0.594 (15.1)	3.0 (38.1)	-

Temper	Form	Condi- tion, Heat Treat- ment	Test Ori- enta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/√in (MN m ^{-1/2})	2.5 (K _{IC} σ _{ys}) in (mm)	Specimen				Ref.
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
HIB 66												
NP	Plate: 0.5 in (12.7 mm) Thick	D, 3	L-S	70(294)	62(425)	23(25)	0.344 (8.7)	(b)	---	---	---	73
			T-S	70(294)	62(429)	19(21)	0.235 (6.0)	(b)	---	---	---	
RSL-77												
WP	Forging:	E, 5	T-S	70(214)	65(445)	20(22)	0.239 (60.7)	(b)	---	---	---	71
			S-L	70(294)	64(440)	17.5(19)	0.187 (4.7)	(b)	---	---	---	
RSL-93												
WP	Plate: 1.5 in (38.1 mm) Thick	E, 2	L-T	70(294)	63(437)	23(25)	0.333 (8.5)	(b)	---	---	---	65
			T-L	70(294)	62(428)	21(23)	0.287 (7.5)	(b)	---	---	---	
			S-L	70(294)	60(414)	19(21)	0.251 (6.4)	(b)	---	---	---	
GB-265												
NP	Plate: 2.5 in (63.5 mm) Thick	F, 6	T-L	70(294)	41(283)	19(21)	0.54 (13.6)	DCB	1.5 (38.1)	10 (254)	3.8 (93)	83

(a) Fabrication and Heat Treatment in accordance with Applicable Military, Federal, ASTM or Aluminum Association Specifications.

(b) Specimen in accordance with ASTM specifications.

COMPOSITION

	Cu	Mg	Si	Fe	Zn	Mn	Cr	Ti	Ni	Pb
A	4.5N	0.5N	1.0N	1.0N	1.0N	0.25N	0.1N	0.15N	-	-
B	1.58	0.69	0.94	0.22	0.72	0.08	0.01	0.04	-	-
C	1.41	0.50	0.97	0.24	0.73	0.14	0.01	0.04	-	-
D	1.3N	0.62N	0.75N	1.0N	0.8N	0.2N	-	0.2N	-	-
E	1.15	0.55N	0.75N	0.75N	0.85N	0.2N	-	0.2N	-	-
F	1.04	0.66	0.81	0.42	0.74	-	-	0.01	-	-

65K

1. Solution Heat Treated, Cold Worked and Artificially Aged in Accordance with MIL-Specification MIL-H-6088D and Aluminum Standards and Data.

940F (778K), Water Quench; 1.5-2.5%; Age 319-373F (433-463K)

931F (773K), Water Quench; Age 310-364F (429-458K)

4. 911F (773K), Water Quench; Stretch 1.5-3%; Age 340F (444K), 8-12 hr

5. 951F (773K), Water Quench; Age 319-373F (433-463K)

6. 911F (778K), 3 hr, Quench; Age 319F (433K), 10 hr

(a) Fabrication and Heat Treatment in accordance with Applicable Military, Federal, ASTM or Aluminum Association Specifications.

(b) Specimen in accordance with ASTM specifications.

COMPOSITION

	Cu	Mn	Si	Fe	Zn	Cr	Ti	Ni	Pb
A	4.5N	0.5N	1.0N	1.0N	1.0N	0.25N	0.1N	0.15N	-
B	1.58	0.60	0.94	0.22	0.72	0.08	0.01	0.04	-
C	1.41	0.50	0.97	0.24	0.73	0.14	0.01	0.04	-
D	1.3N	0.62N	0.75N	1.0N	0.8N	0.2N	-	0.2N	-
E	1.15	0.5N	0.7N	0.5N	0.8N	0.2N	-	0.2N	-
F	1.04	0.66	0.81	0.42	0.74	-	-	0.01	-

HEAT TREATMENT

1. Solution Heat Treated, Cold Worked and Artificially Aged in Accordance with MIL Specification MIL-IL-60880 and Aluminum Standards and Data.

940F (778K), Water Quench; 1.5-2.5%; Age 319-373F (433-463K)
931F (773K), Water Quench; Age 310-364F (420-458K)
911F (773K), Water Quench; Stretch 1.5-3%; Age 340F (444K), 8-12 Hr
931H (773K), Water Quench; Age 319-373F (433-463K)
911H (773K), 3 Hr. Quench; Age 319F (433K), 10 Hr

ALUMINUM, Copper Alloy: 2020

Table 44

ALUMINUM, Copper Alloy: 2020												
Temper	Form	Composition, Heat Treatment	Test Orientation	Temp. °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/in (MN m ^{-3/2})	2.5 ($\frac{K_{IC}^2}{\sigma_{ys}}$) in (mm)	Specimen				Ref.
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
T6S1	Plate: 1.375 in (34.9 mm) Thick	A _c (a)	L-T	70(294)	76(524)	22(24)	0.209 (5.3)	Bend	1.375(34.9)	3.0 (76.2)	---	38
			T-L	70(294)	77(531)	18(21)	0.152 (3.9)	Bend	1.375(34.9)	3.0 (76.2)	---	

(a) Heat Treatment in Accordance with Applicable Military, ASTM or Aluminum Association Specifications.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Cd	Li	Tl
A	4.5N	0.03M	0.4M	0.4M	0.5N	0.25M	0.23N	1.3N	0.1M

ALUMINUM, Copper Alloy: 2021 and 2219 (Sheet 1 of 2)

Table 45

Temper	Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/in (MN m ^{-3/2})	2.5 $\frac{K_{IC}}{\sigma_{ys}}$ in (mm)	Specimen				Ref.
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
2021 T6		A, ~	T-S	70(294)	60(414)	23(25)	0.36" (9.3)	(b)	---	---	---	60
2021 T81	Plate: 1.0 in (25.4 mm) thick	C, 1	T-L	70(294)	61(421)	23(25)	0.355(9.0)	Bend	1.0 (25.4)	-	-	4
			T-L	-100(200)	65(448)	27(29)	0.431(10.9)	Bend	1.0 (25.4)	-	-	
		A, (a)	T-L	-321(78)	73(503)	32(35)	0.480(12.2)	Bend	1.0 (25.4)	-	-	
		B, 2	T-L	-423(27)	80(552)	40(44)	0.625(15.9)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	5a
	Plate: 0.5 in (12.7 mm) thick		L-T	70(294)	65(448)	27(29)	0.431(10.9)	Bend	0.500(12.7)	1.0 (25.4)	0.500(12.7)	4a
			T-L	70(294)	*(441)	23(25)	0.323(8.2)	Bend	0.500(12.7)	1.0 (25.4)	0.500(12.7)	
	Plate: 1.0 in (25.4 mm) thick	A, (a)	L-T	70(294)	66(455)	36(49)	0.745(18.9)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	37
			T-L	70(294)	65(448)	24(26)	0.342(8.7)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
	Plate: 0.5 in (12.7 mm) thick	A, (a)	L-T	70(294)	65(448)	26(28)	0.4 (10.3)	(b)	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	37
			T-L	70(294)	64(441)	21(23)	0.269(6.8)	(b)	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	
2219 T87	Plate: 1 in (25.4 mm) Thick	B, (a)	L-T	70(294)	58(409)	33(36)	0.809(20.5)	SIN	1.0 (25.4)	5.0 (127.0)	1.5 (40.6)	40
		B, (a)	T-L	70(294)	55(379)	30(33)	0.743(18.9)	SIN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	
	Plate: 2.5 in (63.5 mm) Thick	B, 3	T-S	72(296)	55(379)	37(40)	1.131(28.7)	Bend	1.25 (31.8)	2.5 (63.5)	1.25 (31.8)	36
				-320(73)	67(462)	42(44)	0.982(24.9)	Bend	1.25 (31.8)	2.5 (63.5)	1.25 (31.8)	
				-423(21)	73(503)	47(31)	1.036(26.3)	Bend	1.25 (31.8)	2.5 (63.5)	1.25 (31.8)	

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Aluminum, Copper Alloy: 2021 and 2219 (Sheet 2 of 2)

Table 45 (Cont.)

Aluminum, Copper Alloy: 2021 and 2219 (Sheet 2 of 2)												
Table 4S (Cont.)												
Temper	Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI/in (MN m ^{-3/2})	2.5 ($\frac{K_{IC}^2}{\sigma_{ys}}$) in (mm)	Specimen				Ref.
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
2219	Plate:	B, -	-	70 (294)	51 (352)	33 (36)	1.047 (26.6)	Band	1.40 (35.6)	3.0 (76.2)	1.5 (38.1)	44
1851		B, (A)	L-T	70 (294)	59 (407)	38 (41)	1.037 (26.4)	SEN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	40
	Plate: 1 in (25.4 mm) Thick		T-L	70 (294)	58 (408)	37 (40)	1.017 (25.8)	SEN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	
		B, (B)	L-T	70 (294)	51 (352)	36 (39)	1.246 (31.6)	(b)	1.375 (34.9)	2.75 (70.0)	1.375 (34.9)	57
	Plate: 1.375 in (34.9 mm) Thick		T-L	70 (294)	57 (393)	32 (35)	0.788 (20.0)	(b)	1.375 (34.9)	2.75 (70.0)	1.375 (34.9)	
		B, (A)	T-L	70 (294)	50 (345)	29 (32)	0.841 (21.4)	(b)	1.375 (34.9)	3.0 (76.2)	1.55 (39.4)	56

(a) Fabrication and Heat Treatment in Accordance with Applicable Military, Federal, or Aluminum Association Specification
(b) Specimen in accordance with ASTM Recommendations

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Al	V	Cd	Sn
A	6.35	0.025	0.20	0.30	0.55	0.10	0.065	0.10	0.185	0.150
B	6.35	0.020	0.20	0.30	0.55	0.10	0.065	0.10	0.185	-
C	6.08	0.05	0.07	0.11	0.25	0.01	0.05	0.08	0.15	0.11

HEAT TREATMENT

- 985F (530K), 2 Hr, Oil Quenched, Preaged 300F (422K), 1 Hr; Stretch 1.5% Maximum Age 325F (436K), 24 Hrs.
- 990F (536K), Water Quenched, Preaged 300F (422K), 1 Hr, Stretch 1.0% Maximum, Aged 325F (436K), 16 Hr
- Annealed 1550F (1117K) Argon Atmosphere, 8 Hr, Furnace Cool

ALUMINUM, Copper Alloy: 2024, 2124, D19 5090 and A-BAG1 (Sheet 1 of 2) Table 46

Temper	Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Yield Strength ksi (N/mm ²)	Typical K _{IC} ksi√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{UT}}$) ² in (mm)	Specimen				Ref	
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)		
2024 T851	Plate: 1.375 in (34.9 mm) Thick	A ₁ (n)	T-L	70 (294)	64 (441)	20 (22)	0.244 (6.2)	Bend	1.375 (34.9)	3.0 (76.2)	1.51 (38.4)	39
			T-L	-112 (193)	69 (476)	22 (24)	0.254 (6.5)	Bend	1.375 (34.9)	3.0 (76.2)	1.51 (38.4)	
			T-L	-320 (78)	79 (545)	22 (24)	0.200 (5.1)	Bend	1.375 (34.9)	3.0 (76.2)	1.51 (38.4)	
			T	70 (294)	66 (455)	24 (26)	0.331 (8.4)	Bend	1.375 (34.9)	3.0 (76.2)	1.51 (38.4)	
				70 (294)	66 (455)	33 (36)	0.625 (15.9)	(b)	---	---	---	37
	Preformed Plate: 1.5 in (38.1 mm) Thick	A ₁ (n)	T-L	70 (294)	65 (448)	32 (35)	0.606 (15.4)	(b)	---	---	---	
			L-L	70 (294)	62 (427)	32 (35)	0.625 (15.9)	(b)	0 (25.4)	2.0 (50.8)	1.0 (25.4)	37
			T-L	70 (294)	61 (420)	25 (27)	0.42 (10.5)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			L-T	70 (294)	56 (386)	25 (27)	0.498 (12.6)	Bend	0.55 (14)	1.02 (26)	0.55 (14)	27
			T	70 (294)	56 (386)	22 (24)	0.386 (9.8)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
2024 T851	Plate: 2.2 in (55.9 mm) Thick	A ₁ (n)	L-T	300 (422)	55 (379)	27 (29)	0.602 (15.3)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	116
			T-L	300 (422)	54 (372)	22 (24)	0.415 (10.5)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	
			L-T	70 (294)	63 (434)	27 (29)	0.459 (11.7)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	
			T-L	70 (294)	64 (441)	22 (24)	0.295 (7.5)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	
			L-S	70 (294)	61 (421)	31 (34)	0.646 (16.4)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	
	Extrusion: 1.45 in (36.8 mm) Thick	A ₁ (n)	L-T	-65 (219)	67 (462)	26 (28)	0.376 (9.6)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	
			T-L	-65 (219)	67 (462)	23 (25)	0.295 (7.5)	CT	0.75 (19.0)	1.5 (38.1)	0.75 (19.1)	
			L-T	70 (294)	69 (476)	30 (33)	0.480 (10.2)	Bend	1.01 (25.7)	3.0 (76.2)	---	42
			T-L	70 (294)	66 (455)	18 (20)	0.165 (4.2)	Bend	0.375 (9.5)	0.937 (23.8)	---	
			L-T	70 (294)	65 (448)	24 (26)	0.341 (8.7)	Bend	0.750 (19.1)	1.5 (38.1)	---	41
2024 T852	Forging: 2.0 in (50.8 mm) Thick	B ₁ 1	T-L	70 (254)	64 (441)	22 (24)	0.295 (7.5)	Bend	0.750 (19.1)	1.5 (38.1)	---	

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ALUMINUM, Copper Alloy: 2024, 2124, DTD 5090 and A-4001 (Sheet 2 of 3) Table 46 (Cont.)

Temper	Form	Compo- sition, Heat Treat- ment	Test Method	Yield Strength ksi (MN/m ²)	Typical K _{IC} ksi/in. ^{3/2} (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen			Ref	
							Type	Thickness in (mm)	Width in (mm)		Crack Length in (mm)
T4 2124 T851	Plate: 1 in (25.4 mm) Thick	C, 1	L-T	56(386)	30(33)	0.717(18.2)	Bend	2.0 (50.8)	4.0 (101.6)	---	41
			T-L	58(400)	17(19)	0.215(5.5)	Bend	2.0 (50.8)	4.0 (101.6)	---	
			S-L	54(372)	16(17)	0.219(5.6)	Bend	0.5 (12.7)	1.0 (25.4)	---	
			T-L	48(331)	31(34)	0.41 (10.4)	SEN	1.0 (25.4)	5.0 (127)	1.6 (40.6)	40
T651	Plate: 2 in (50.8 mm) Thick	E, (a)	L-T	66(455)	24(26)	0.331(8.4)	CT	0.75 (19.1)	2.0 (50.8)	1.0 (25.4)	110
			T-L	65(448)	23(25)	0.313(8.0)	CT	0.75 (19.1)	2.0 (50.8)	1.0 (25.4)	
T851	Plate: 3 in (76.2 mm) Thick	D, 2	L-T	54(379)	41(45)	1.441(36.6)	(b)	---	---	---	72
			T-S	50(345)	24(27)	0.576(14.6)	Bend	0.5 (12.7)	1.0 (25.4)	---	60
T851	Plate: 2 in (50.8 mm) Thick	D, -	T-S	58(400)	22(24)	0.360(9.1)	Bend	0.5 (12.7)	1.0 (25.4)	---	
			T-S	61(421)	24(27)	0.387(9.8)	Bend	0.5 (12.7)	1.0 (25.4)	---	

(a) Fabrication and Heat Treatment in accordance with Military, Federal, ASTM or Aluminum Association Specifications.

(b) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	Cu	Fe	Si	Mn	Zn	Ti	Cr	Ni	Pb
A	4.3N	1.5N	0.5N	0.6N	0.25N	-	0.1N	-	-
B	4.63	1.54	0.11	0.53	0.07	0.02	-	-	-
C	4.56	1.69	0.14	0.12	0.65	0.03	-	-	-
D	4.35N	1.5N	0.5N	0.6N	0.2N	-	-	0.5N	0.05N
E	4.35N	1.5N	0.3N	0.2N	0.6N	0.25N	0.1N	-	-

HEAT TREATMENT

1. Solution Heat Treated, Cold Worked and Artificially Aged in accordance with Mil Specification MIL-II-6088D or Aluminum Standards and Data, Aluminum Association, April 1968

2. 922F (768K), Water Quench; Stretch 1.5-2.5t

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COMPOSITION

	Cu	Fe	Si	Mn	Zn	Ti	Cr	Ni	Pb
A	4.3N	1.5N	0.5N	0.6N	0.25N	-	0.1N	-	-
B	4.63	1.54	0.15	0.11	0.53	0.07	0.02	-	-
C	4.56	1.69	0.14	0.12	0.65	0.08	0.03	-	-
D	4.35N	1.5N	0.5N	0.6N	0.2N	-	-	0.5N	0.05N
E	4.35N	1.5N	0.3N	0.2N	0.6N	0.25N	0.1N	-	-

HEAT TREATMENT

- Solution Heat Treated, Cold Worked and Artificially Aged in accordance with Mil Specification MIL-H-6088D or Aluminum Standards and Data, Aluminum Association, April 1968
- 922F (768K), Water Quench; Stretch 1.5-2.5%

ALUMINUM, Copper Alloy: 2618, RR58, UTD 731, CM 0031/4D, A-U2GN

Table 47

Tempor	Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (MN/m ²)	Typical K _{IC} KSI√in (MN m ^{-3/2})	2.5 ($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref.																																				
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)																																					
2618																																																
T651	Plate: 1 in (25.4 mm) Thick	A, (a)	T-L	70(294)	58(400)	33(37)	0.85 (22.6)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	37																																				
RR58																																																
MP	Plate: 3 in (76.2 mm) Thick	B, -	L-T	70(294)	60(414)	22(24)	0.336 (8.6)	Bend	0.75 (19.1)	3.0 (76.2)	1.0 (25.4)	62																																				
		B, -	T-L	70(294)	58(400)	19(21)	0.268 (6.8)	Bend	0.75 (19.1)	3.0 (76.2)	1.0 (25.4)																																					
		B, -	S-L	70(294)	55(379)	20(22)	0.331 (8.4)	Bend	0.75 (19.1)	3.0 (76.2)	1.0 (25.4)																																					
MP	Forging	B, -	T-L	70(294)	61(421)	24(26)	0.387 (9.8)	Bend	1.4 (35.6)	0.38(9.7)	0.49(12.4)																																					
UTD 731																																																
MP	Forging	B, -	L-T	70(294)	58(400)	21(23)	0.328 (8.3)	Bend	0.38 (9.7)	1.5 (38.1)	0.34 (8.6)	62																																				
			T-S	70(294)	58(400)	21(23)	0.328 (8.3)	Bend	0.38 (9.7)	1.5 (38.1)	0.34 (8.6)																																					
			S-L	70(294)	57(393)	16(17.6)	0.197 (5.0)	Bend	0.25 (6.4)	0.75(19.1)	0.30 (7.6)																																					
CM 003/4D																																																
MP	Plate: 1.5 in (38.1 mm) Thick	C, 1	L-T	70(294)	61(423)	23(25)	0.355 (9.0)	(b)	---	---	---	72																																				
	Plate: 3 in (76.2 mm) Thick	C, 1	L-T	70(294)	60(417)	20(22)	0.278 (7.1)	(b)	---	---	---																																					
			L-T	70(294)	58(399)	17(19)	0.215 (5.5)	(b)	---	---	---																																					
			S-L	70(294)	55(376)	16(18)	0.212 (5.4)	(b)	---	---	---																																					
A-U2 GN																																																
T 651		A, -	T-S	70(294)	57(393)	21(23)	0.339 (8.6)	Bend	0.5 (12.7)	1.0 (25.4)	---	62																																				
T 652		A, -	L-T	70(294)	58(400)	24(26)	0.428 (10.9)	Bend	0.5 (12.7)	1.0 (25.4)	---																																					
COMPOSITION																																																
<table><tr><td>Cu</td><td>Mg</td><td>Si</td><td>Fe</td><td>Mn</td><td>Zn</td><td>Ti</td><td>Pb</td><td>Ni</td></tr><tr><td>2.3N</td><td>1.5N</td><td>0.25M</td><td>1.1N</td><td>-</td><td>-</td><td>0.07N</td><td>-</td><td>1.05N</td></tr><tr><td>2.5N</td><td>1.5N</td><td>0.2N</td><td>1.0N</td><td>-</td><td>-</td><td>0.1N</td><td>-</td><td>1.2N</td></tr><tr><td>2.25N</td><td>1.5N</td><td>0.25M</td><td>1.15N</td><td>0.2M</td><td>0.1M</td><td>-</td><td>-</td><td>0.05M</td></tr></table>													Cu	Mg	Si	Fe	Mn	Zn	Ti	Pb	Ni	2.3N	1.5N	0.25M	1.1N	-	-	0.07N	-	1.05N	2.5N	1.5N	0.2N	1.0N	-	-	0.1N	-	1.2N	2.25N	1.5N	0.25M	1.15N	0.2M	0.1M	-	-	0.05M
Cu	Mg	Si	Fe	Mn	Zn	Ti	Pb	Ni																																								
2.3N	1.5N	0.25M	1.1N	-	-	0.07N	-	1.05N																																								
2.5N	1.5N	0.2N	1.0N	-	-	0.1N	-	1.2N																																								
2.25N	1.5N	0.25M	1.15N	0.2M	0.1M	-	-	0.05M																																								
(a) Fabrication and Heat Treatment in accordance with Military, Federal, ASTM or Aluminum Association Specifications.																																																
(b) Specimen in accordance with ASTM Recommendations.																																																
WAT TRIATHLON																																																
1. 985F (803K), Water Quenched; Stretch 1.5-2.5%; Aged 373F (463F)																																																

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Tl	Pb	Ni
A	2.3N	1.5N	0.25M	1.1N	-	-	0.07N	-	1.05N
B	2.5N	1.5N	0.2M	1.0N	-	-	0.1N	-	1.2N
C	2.25N	1.5N	0.25M	1.15N	0.2M	0.1M	-	0.05M	1.1N

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(a) Fabrication and Heat Treatment in accordance with Military, Federal, ASTM or Aluminum Association Specifications.
 (b) Specimen in accordance with ASTM Recommendations.

IP AT FRIATMINT

1. 985F (803K), Water Quenched; Stretch 1.5-2.5%; Aged 373F (463F)

ALUMINUM, Zn-Mg Alloy: 7001, 7049 and 7050 (Sheet 1 of 2) Table 48

Temper	Form	Compo- sition, Heat- Treat- ment	Test Orienta- tion	Temp °F (°C)	Yield Strength KSI (N/mm ²)	Typical K _{IC} KSI√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{ys}$) ² in (mm)	Specimen				Ref
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
7001 T75	Plate: 1.375 in (34.9 mm) Thick	A ₁ (a)	L-T	70 (294)	71 (490)	24 (26)	0.286 (7.3)	Bend	1.37 (34.8)	3.0 (76.2)	1.5 (38.1)	38
			T-L	70 (294)	70 (483)	22 (24)	0.247 (6.3)	Bend	1.37 (34.8)	3.0 (76.2)	1.5 (38.1)	
	Extrusion: 0.2 in (5.1 mm) Thick	B ₁	L-T	70 (294)	77 (531)	20 (22)	0.169 (4.3)	SEN	0.180 (4.6)	2.0 (50.8)	0.67 (17)	48
			T-L	70 (294)	78 (537)	20 (22)	0.164 (4.2)	SEN	0.180 (4.6)	2.0 (50.8)	0.67 (17)	
	Forging: 6.0 in (152.4 mm) Thick	B ₁ -	T-L	70 (294)	70 (483)	21 (23)	0.255 (5.7)	SEN	0.250 (6.3)	2.0 (50.8)	---	49
			T-L	70 (294)	71 (490)	16 (17)	0.126 (3.2)	CN	0.185 (4.7)	3.0 (76.3)	---	
7049 T76	Forging: 5 in (127 mm) Thick	C ₁ (a)	S-T	70 (294)	---	16 (17)	---	NOL	1.0 (25.4)	0.813 (20.6)	0.5 (12.7)	
			L-	70 (294)	64 (441)	32 (35)	0.62 (15.8)	(b)	---	---	---	84
	Extrusion, Integrally Stiffened: 18 x 11 x 3 in (457 x 279 x 76 mm)	D ₁ (a)	L-T	75 (297)	75 (517)	28 (31)	0.348 (8.9)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	97
			T-L	75 (297)	75 (517)	25 (27)	0.278 (7.1)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
	Extrusion, 20 x 3.3 x 3.5 (508 x 84 x 89 mm)	D ₁ (a)	S-T	75 (297)	68 (469)	20 (22)	0.216 (5.5)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			L-T	-65 (219)	79 (545)	25 (27)	0.250 (6.4)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
T-L			-65 (219)	78 (538)	23 (25)	0.217 (5.5)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
L-T			70 (294)	73 (503)	33 (36)	0.511 (13)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
Extrusion: 20 x 3.3 x 3.5 in (508 x 84 x 89 mm)	D ₁ (a)	T-L	70 (294)	68 (469)	22 (24)	0.424 (10.8)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
		L-T	-65 (219)	77 (531)	31 (34)	0.477 (12.1)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
		T-L	-65 (219)	70 (483)	20 (22)	0.204 (5.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)		
		L-T	70 (294)	76 (524)	33 (36)	0.471 (12)	CI	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	97	
7049 T76	Extrusion: 20 x 3.3 x 3.5 in (508 x 84 x 89 mm)	D ₁ (a)	T-L	70 (294)	69 (476)	20 (22)	0.210 (5.3)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			L-T	-65 (219)	80 (552)	30 (33)	0.352 (8.9)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			T-L	-65 (219)	72 (496)	29 (31)	0.174 (4.4)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	

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ALUMINUM, Zn-Mg Alloy. 7001, 7049 and 7050 (Sheet 2 of 2)

Table 48 (Cont.)

Temper	Form	Composition, Heat Treatment	Test Orientation	Temp °F (°K)	Yield Strength KSI (N/mm ²)	Typical K_{IC} KSI√in (MN/m ^{3/2})	$2.5\left(\frac{K_{IC}}{\sigma_{ys}}\right)^2$ in (mm)	Specimen			Ref
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)

7050	Plate: 4 in (102 mm) Thick	E,	L-T	70(294)	67(462)	35(38)	0.682(17.3) CT	1.25(31.8)	2.5 (63.5)	1.25(38.1)	116
T7E56	Hand Forging: 5 x 10 in (127 x 254 mm)	F,-	T-L	70(294)	64(70)	29(32)	0.513(13.0) Bend	0.75(19.1)	1.5 (38.1)	0.75(19.1)	120

(a) Heat Treatment in Accordance with Applicable Military, Federal, ASTM or Aluminum Association Specifications.
 (b) Specimen in Accordance with ASTM Recommendations.

COMPOSITION

	Cu	Ni	Fe	Si	Mn	Zn	Cr	Ti	Zr
A	2.1N	3.0N	0.4N	0.35N	0.3N	7.4N	0.28N	0.2N	-
B	2.26	3.03	0.16	0.12	0.04	7.61	0.21	0.02	-
C	1.42	2.45	0.13	0.07	0.01	7.5	0.16	-	-
D	1.5N	2.5N	0.35N	0.25N	0.2N	7.6N	0.15N	0.1N	-
E	2.31	2.44	0.07	0.04	0.00	6.35	0.01	0.03	0.13

ALUMINUM, Zn-Mg Alloy: 7007

Table 49

Temper	Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp °F (°K)	Yield Strength KSI (KN/m ²)	Typical K _{IC} KSI√in (MN m ^{-3/2})	2.5 ($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref.
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
7007 T6	Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70(294)	73(503)	44(48)	0.903(23.1)	(b)	1.0 (25.4)	2.0(50.8)	1.0 (25.4)	37
			T-L	70(294)	69(476)	37(40)	0.719(18.3)	(b)	1.0 (25.4)	2.0(50.8)	1.0 (25.4)	
			T-L	70(294)	65(448)	32(35)	0.606 (15.4)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	58
			T-L	-321(77)	80(552)	23(25)	0.207 (5.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			T-L	-423(22)	85(586)	28(193)	0.271 (6.9)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
7007 T6	Plate: 1.0 in (25.4 mm) Thick	B, (a)	L-T	70(294)	73(503)	46(50)	0.999(25.2)	Bond	1.0 (25.4)	2.0(50.8)	1.0 (25.4)	43
			T-L	70(294)	69(476)	37(40)	0.685(17.4)	Bond	1.0 (25.4)	2.0(50.8)	1.0 (25.4)	

(a) Fabrication and Heat Treatment in accordance with Aluminum Association Specifications.
(b) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr	Zr	Ag
A	0.25%	1.8%	(0.4% total)	0.4%	6.5%	6.5%	0.04%	0.12%	0.12%	-
B	0.06	1.7%	0.05	0.11	6.21	6.55	0.03	0.11	0.10	-

HEAT TREATMENT

1. 860F (734K), Controlled Moderate Quench; Stretched 1.5 to 3%; Aged 275F (40K), 16 hr

ALUMINUM, Zn-Mg Alloys: 7075, DTD 5050, DTD 5074, BSL 95, AZ 74, and 7175 (Sheet 1 of 4) Table 50

Temper	Form	Composition, Heat Treatment	Test Orientation	Temp, °F (°C)	Yield Strength ksi (N/mm ²)	Typical K _{IC} ksi√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) in (mm)	Specimen				Ref
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
7075 T6	Plate: 3 in (76.2 mm) Thick	A,1	T-S	70(294)	63(435)	26(28)	0.459(11.7)	(b)	---	---	---	76
	Plate: 0.5 in (12.7 mm) Thick	A, (a)	T-L	70(294)	73(503)	25(27)	0.290(7.4)	(b)	0.5 (12.7)	1.0 (25.4)	0.5 (12.7)	37
	Plate: 1.375 in (44.5 mm) Thick	A, (a)	T-L	70(294)	74(510)	19(21)	0.165(4.2)	(b)	1.75 (44.4)	3.0 (76.2)	1.75 (44.4)	
		A, (a)	S-L	70(294)	---	15(16)	---	(b)	1.75 (44.4)	3.0 (76.2)	1.75 (44.4)	
7051	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	75(517)	28(31)	0.350(8.9)	Bend	1.375(34.9)	3.0 (76.2)	1.5 (38.1)	38
		A, (a)	T-L	70(294)	78(537)	23(25)	0.218(5.5)	---	---	---	---	
	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-L	70(294)	78(537)	21(23)	0.180(4.6)	Bend	1.390(35.3)	3.0 (76.2)	1.5 (38.1)	39
		A, (a)	T-L	-112(193)	83(572)	23(25)	0.193(4.9)	Bend	1.390(35.3)	3.0 (76.2)	1.5 (38.1)	
7051	Plate: 4 in (101.6 mm) Thick	A, (a)	T-L	-320(78)	92(633)	25(27)	0.185(4.7)	Bend	1.390(35.3)	3.0 (76.2)	1.5 (38.1)	
		A, 2	T-S	70(294)	67(459)	22(24)	0.270(6.8)	(b)	---	---	---	76
	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-L	70(294)	79(544)	26(28)	0.277(7.0)	(b)	0.625(15.9)	1.25 (31.8)	0.625(15.9)	57
		A, (a)	T-L	70(294)	75(517)	25(27)	0.278(7.1)	(b)	0.625(15.9)	1.25 (31.8)	0.625(15.9)	
7175	Extrusion: 3.5 in (88.9 mm) Thick	A, (a)	L-T	70(294)	75(517)	31(34)	0.427(10.8)	(b)	1.5 (30.1)	3.0 (76.2)	1.5 (38.1)	
		A, (a)	T-L	70(294)	67(462)	21(23)	0.246(6.3)	(b)	1.5 (30.1)	3.0 (76.2)	1.5 (38.1)	
		A, (a)	S-L	70(294)	61(421)	19(21)	0.242(6.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	61
	Plate: 1.375 in (34.9 mm) Thick	A, (a)	T-L	70(294)	57(393)	28(31)	0.603(15.3)	Bend	1.375(34.9)	3.0 (76.2)	1.5 (38.1)	39
7175		A, (a)	T-L	-112(193)	59(407)	28(31)	0.563(16.6)		1.375(34.9)	3.0 (76.2)	1.5 (38.1)	
		A, (a)	T-L	-320(78)	66(455)	29(32)	0.483(12.3)		1.375(34.9)	3.0 (76.2)	1.5 (38.1)	
	Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70(294)	67(462)	33(36)	0.606(15.4)	SLN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	40
		A, (a)	T-L	70(294)	65(448)	27(29)	0.431(10.9)		1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	

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ALUMINUM, Zn-Ni Alloys: 7075, UTD 5050, UTD 5074, BSL 95, A2 74, and 7175 (Sheet 2 of 4) Table 50 (Cont.)

Temper	Form	Composition, Heat Treatment	Test Orientation	Yield Strength ksi (N/mm ²)	Typical K _{IC} ksi√in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{YS}}$) ² in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
7075 T73511	Plate: 1.0 (25.0 mm) Thick	---	L-T	70(294)	34(37)	0.859(21.8)	Bend	0.55 (14)	1.02 (26)	0.55 (14)	27
			T-L	70(294)	28(31)	0.603(15.3)		1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			T-S	70(294)	27(30)	0.418(10.6)		---	---	---	76
			L-T	70(294)	31(34)	0.855(21.7)	CT	1.25 (31.8)	2.5 (63.5)	1.25 (31.8)	116
7075 T73511	Forging: 1.1 in (27.9 mm) Thick	---	L-T	70(294)	33(36)	0.809(20.5)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			L-L	70(294)	22(24)	0.359(9.1)		1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			L-S	70(294)	27(30)	0.625(15.9)	Bend	0.5 (12.7)	1.0 (25.4)	---	60
			L-T	70(294)	34(37)	0.706(17.9)	(b)	0.625(15.9)	1.25 (31.8)	0.625(15.9)	37
7075 T7352	Extrusion: 3.5 in (88.9 mm) Thick	A ₁ (a)	F-L	70(294)	30(32)	0.585(14.9)	(b)	0.625(15.9)	1.25 (31.8)	0.625(15.9)	
			L-T	70(294)	35(38)	0.748(19.0)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	
			F-L	70(294)	24(26)	0.428(10.5)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	
			S-L	70(294)	20(22)	0.343(8.7)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	61
7075 T7352	Forging: 2.0 in (50.8 mm) Thick	B ₁ I	L-T	70(294)	31(34)	0.569(14.4)	Bend	0.75 (19.0)	1.5 (38.1)	---	41
			T-L	70(294)	24(26)	0.341(8.7)		0.75 (19.0)	1.5 (38.1)	---	
			L-T	70(294)	40(44)	1.322(33.6)		2.0 (50.8)	4.0 (101.6)	---	
			L-L	70(294)	28(31)	0.784(19.9)		2.0 (50.4)	4.0 (101.6)	---	
7075 T7352	Forging: 6.0 in (152.4 mm) Thick	G ₁ I	S-L	70(294)	26(28)	0.703(17.9)		2.0 (50.4)	4.0 (101.6)	---	
			S-L	70(294)	22(24)	0.386(9.8)	Bend	0.7 (17.8)	1.4 (35.6)	0.7 (17.8)	111
			L-T	70(294)	20(22)	0.319(8.1)	Bend	0.7 (17.8)	1.4 (35.6)	0.7 (17.8)	
			L-T	70(294)	30(32)	0.692(17.6)	Bend	0.5 (12.7)	1.0 (25.4)	---	60
7075 T7651	Plate: 2 in (50.8 mm) Thick	A ₁ (a)	L-T	80(299)	27(29)	0.431(11)	CT	0.8 (20.3)	2.0 (50.8)	1.0 (25.4)	119

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ALUMINUM, Zn-Mg Alloys: 7075, UTD S050, DND S074, BSL 95, AZ 74, 7175 (Sheet 4 of 4) Table 50 (Cont.)

Item	Form	Composition, Heat Treatment	Test Orientation	Temp of F (°K)	Yield Strength KSI (N/m ²)	Typical K _{IC} KSI/in (MN/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
1736	Die Forging: 3 in (76.2 mm) Max. Thickness	H ₁₃	L-T	70(294)	72(496)	35(38)	0.591(15)	(b)	---	---	---	37
			T-L	70(294)	67(462)	26(28)	0.376(9.6)	(b)	---	---	---	
			S-L	70(294)	---	27(29)	---	(b)	---	---	---	
	Forging: 2.5 in (63.5 mm) Square	H ₁₃	T-L	70(294)	66(455)	23(25)	0.304(7.7)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	99
			S-T	70(294)	65(448)	32(35)	0.606(15.4)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	---
			S-T	0(256)	66(455)	27(29)	0.419(10.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	---
			S-T	65(219)	67(462)	26(28)	0.376(9.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	---

(a) Fabrication and Heat Treatment in accordance with Aluminum Association Specifications.
(b) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	Cu	Al	Si	Fe	Mn	Zn	Cr	Ti	Ni	Pb	Ag
A	1.6N	2.5N	0.5N	0.7N	0.3N	5.6N	0.3N	0.2H	-	-	-
B	1.6	2.50	0.10	0.13	0.02	5.65	0.19	0.03	-	-	-
C	1.4	2.60	0.10	0.14	0.02	5.68	0.19	0.03	-	-	-
D	1.4N	2.5N	-	-	0.15N	5.8N	0.2N	-	-	-	-
E	1.6N	2.5N	0.4N	0.5N	0.3N	5.8N	-	-	0.05N	0.17N	-
F	0.9N	2.7N	0.5N	0.5N	0.1N	5.85N	-	0.3N	0.05N	0.17N	-
G	0.92	2.5	0.09	0.15	<0.01	5.85	-	-	-	-	(Cr + Mn 0.18-0.5)
H	1.5N	2.5N	0.15N	0.2N	0.01N	5.6N	0.24N	0.2	-	-	0.39
I	1.55	2.57	0.2	0.22	0.07	5.7	0.18	<0.2	-	-	-

(a) Fabrication and Heat Treatment in accordance with Aluminum Association Specifications.
(b) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Cr	Ti	Ni	Pb	Ag
A	1.6N	2.5N	0.5N	0.7N	0.3N	5.6N	0.3N	0.2N	-	-	-
B	1.6	2.50	0.10	0.13	0.02	5.65	0.19	0.03	-	-	-
C	1.4	2.60	0.10	0.14	0.02	5.68	0.19	0.03	-	-	-
D	1.4N	2.5N	-	-	0.15N	5.8N	0.2N	-	-	-	-
E	1.6N	2.5N	0.4N	0.5N	0.3N	5.8N	-	-	0.05N	0.17N	-
F	0.9N	2.7N	0.5N	0.5N	0.1N	5.85N	-	0.3N	0.05N	0.17N	-
G	0.92	2.5	0.08	0.15	<0.01	5.85	-	-	-	-	0.39
H	1.5N	2.5N	0.15N	0.2N	0.01N	5.6N	0.24N	0.1N	-	-	-
I	1.55	2.27	<0.2	0.23	0.07	5.7	0.18	<0.2	-	-	-

(Cr + Mn 0.18-0.5)

HEAT TREATMENT

1. Stress Relieved and Aged to meet requirements of paragraph 4.10 of Federal Spec. QQA-367g, Paragraph 4.6.5.1 MIL Spec. N1LA-22771C.
2. 859F (733K), Water Quenched, Stretch 1.5-2.5%; Aged 275F (408K).
3. Proprietary Heat Treatment.

ALUMINUM, Zn-Mg Alloys: 7178 and 7651 and 7652 (Sheet 1 of 2)

Temper	Form	Compo- sition, Heat Treat- ment	Test Orien- tation	Temp σ_F ($^{\circ}$ F)	Yield Strength KSI (N/mm ²)	Typical K_{IC} KSI \sqrt{in} (MN m ^{-3/2})	2.5 ($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref.
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
7178 T651	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	83(572)	23(25)	0.192(4.9)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	37
			T-L	70(294)	78(538)	20(138)	0.164(4.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	61
	Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70(294)	81(558)	26(28)	0.257(6.5)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
			T-L	70(294)	81(558)	23(25)	0.202(5.1)	(b)	1/0 (25.4)	2.0 (50.8)	1.0 (25.4)	
T6510	Extrusion: 0.18 to 2.2 in (4.6 to 55.9 mm) Thick	A, (a)	L-T	70(294)	86(593)	21(23)	0.150(3.8)	SEN	0.18 min (4.6)	0.9 min (22.8)	0.4 min (10.2)	42
			T-L	70(294)	79(545)	21(23)	0.177(4.5)	SEN	0.18 min (4.6)	0.9 min (22.8)	0.4 min (10.2)	
7178 T7651	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	70(294)	73(503)	26(28)	0.317(8.1)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	37
			T-L	70(294)	71(490)	21(23)	0.219(5.6)	(b)	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
	Plate: 2 in (50.8 mm) Thick	A, (a)	T-L	70(294)	64(441)	22(24)	0.295(7.5)	(b)	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
	Plate: 1.0 in (25.4 mm) Thick	A, (a)	L-T	70(294)	71(490)	30(33)	0.447(11.3)	(b)	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
			T-L	70(294)	71(490)	28(30)	0.391(9.9)	(b)	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
T6511	Extrusion: 3.5 in (88.9 mm) Thick	A, (a)	L-T	70(294)	78(538)	23(25)	0.217(5.5)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	
			T-L	70(294)	69(476)	16(17)	0.134(3.4)	(b)	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	
			S-L	70(294)	62(427)	14(15)	0.127(3.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	61
	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-T	70(294)	83(572)	22(24)	0.175(4.4)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.4)	
			T-L	70(294)	83(572)	20(22)	0.145(3.7)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.4)	
T76511	Extrusion: 0.688 in (17.5 mm) Thick	A, (a)	L-T	70(294)	69(476)	29(32)	0.442(11.2)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.9)	
			T-L	70(294)	68(470)	26(28)	0.365(9.3)	(b)	0.625(15.9)	1.25(31.8)	0.625(15.9)	
T62	Extrusion: 0.4 in (10.2 mm) Thick	A, (a)	L-T	70(294)	90(620)	23(25)	0.163(4.1)	(b)	0.404(10.3)	1.5 (38.1)	---	42
			T-L	70(294)	83(573)	23(25)	0.192(4.9)	(b)	0.512(7.9)	0.940(23.9)	---	
(a) Composition, Fabrication and Heat Treatment in accordance with Aluminum Association Specifications (b) Specimen in accordance with ASTM Recommendations												

(a) Composition, Fabrication and Heat Treatment in accordance with Aluminum Association Specifications (b) Specimen in accordance with ASTM Recommendations

Table 52

Temper	Form	Composition, Heat Treatment	Tensile Strength (ksi)	Yield Strength (ksi)	Typical K_{IC} (ksi√in)	$2.5 \left(\frac{K_{IC}}{\sigma_{ys}} \right)^2$ in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
7039 T6	Forging: 4.0 in (101.6 mm) Thick	A, 1	T-L 70(294)	57(393)	19(21)	0.277 (7.0)	WOL	4.0 (101.6)	10.2 (259)	4 (101.6)	45
			T-L 0(256)	59(407)	17(19)	0.208 (5.3)	WOL	4.0 (101.6)	10.2 (259)	4 (101.6)	
6651	Plate: 2.0 in (50.8 mm) Thick	B, 2	T-L 75(294)	49(338)	29(32)	0.877(22.3)	Bend	1.75 (44.5)	3.5 (89)	1.75 (44.5)	4
			- -100(200)	53(365)	30(33)	0.804(20.4)	Bend	1.75 (44.5)	3.5 (89)	1.75 (44.5)	
7001 T6, 4	Plate: 3 in (76.2 mm) Thick	C, (a)	T-L -321(- 78)	58(400)	31(34)	0.715(18.2)	Bend	1.75 (44.5)	3.5 (89)	1.75 (44.5)	
			T-L 70(294)	53(365)	47(51)	1.966(49.9)	Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)	98
			T-L 70(294)	52(359)	40(44)	1.479(37.8)	Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)	
			S-L 70(294)	48(331)	38(31)	0.851(21.6)	CT	1.25(31.8)	2.5 (635)	1.25 (31.8)	

(a) Fabrication, and Heat Treatment in accordance with Aluminum Association Specification
(b) Specimen in accordance with ASTM Recommendations

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Ti	Zr
1	0.14	2.88	0.30	0.49	0.25N	4.0N	0.28	0.14
2	0.04	2.5	0.31	0.49	0.25N	3.75	0.38	0.14
3	0.19	1.43	0.354	0.354	0.45N	4.6N	0.13N	0.13N

HEAT TREATMENT

- 850F (728C), 4 Hr, Aged 320F (433K), 18 Hr
- 850F (728C), 2.5 Hr, Water Quench, Age Room Temperature, 8 Hr, Age 320F (433K), 18 Hr

ALUMINUM, Zn-Mg-Mn Alloy: 7079

Table 53

Temper	Form	Condition, Heat Treat- ment	Test Orienta- tion	Temp σ_F ($^{\circ}$ F)	Yield Strength KSI (MN/m^2)	Typical K_{IC} KSI/in ($\text{MPa m}^{1/2}$)	$2.5 \left(\frac{K_{IC}}{\sigma_F} \right)^2$ in (mm)	Specimen				Ref.	
								Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)		
T6	Plate: 1.0 in (25.4 mm) Thick	A, (a)	T-L	70(294)	75(517)	27(24)	0.215(5.5)	SEN	1.0 (25.4)	5.0 (127.0)	1.6 (40.6)	40	
	Forging: 3.0 in (76.1 mm) Thick	A, 1	L-T	75(297)	91(441)	32(35)	0.625(15.9)	WOL	2.0 (50.8)	2.25(57.3)	1.0 (25.4)	11	
			T-L	75(297)	64(441)	28(31)	0.503(12.7)	WOL	2.0 (50.8)	2.25(57.3)	1.0 (25.4)		
51	Plate: 1.375 in (34.9 mm) Thick	A, (a)	L-T	75(214)	69(476)	33(36)	0.570(14.5)	WOL	2.0 (50.8)	2.25(57.3)	1.0 (25.4)		
			L-T	70(294)	78(533)	21(34)	0.395(10.0)	Bend	1.375(34.9)	3.0 (76.2)	1.5 (38.1)	38	
			T-T	70(294)	75(517)	25(27)	0.277(7.0)	Bend	1.375(34.9)	3.0 (76.2)	1.5 (38.1)		
			T-L	75(294)	61(558)	26(28)	0.258(6.6)	Bend	1.380(35.1)	3.0 (76.2)	1.65(41.9)	39	
6510	Extrusion: 0.5 in (12.7 mm) Thick	A, (a)	T-L	78(78)	91(627)	27(29)	0.220(5.6)	Bend	1.380(35.1)	3.0 (76.2)	1.45(36.8)		
			L-T	70(294)	74(510)	31(34)	0.439(11.1)	SIN	0.5 (12.7)	1.5 (38.1)	0.5 (12.7)	42	
			T-L	70(294)	71(490)	29(32)	0.417(10.6)	SIN	0.5 (12.7)	1.5 (38.1)	0.5 (12.7)		
			L-T	70(294)	71(490)	28(31)	0.389(9.9)	Bend	0.75 (19.1)	1.5 (38.1)	---	41	
652	Forging: 2.0 in (50.8 mm) Thick	B, (b)	T-L	70(294)	65(448)	25(27)	0.370(9.4)	Bend	0.75 (19.1)	1.5 (38.1)	---		
			C, (b)	L-T	70(294)	64(441)	30(33)	0.549(13.9)	Bend	2.0 (50.8)	4.0 (101.6)	---	
				T-L	70(294)	58(400)	24(26)	0.428(10.9)	Bend	2.0 (50.8)	4.0 (101.6)	---	
				S-L	70(294)	58(400)	18(20)	0.241(6.1)	Bend	0.5 (12.7)	1.0 (25.4)	---	

(a) Fabrication, and Heat Treatment in accordance with Military, Federal, ASTM or Aluminum Assoc. Specifications
 (b) Fabrication and Heat Treatment in accordance with Military, Federal, ASTM or Aluminum Assoc. Specifications

COMPOSITION

	Cu	Zn	Mg	Si	Fe	Mn	Cr	Ti
A	0.6N	4.3N	3.3N	0.3N	0.4N	0.2N	0.18N	0.1N
B	0.76	4.57	3.48	0.11	0.18	0.18	0.14	0.03
C	0.72	4.60	3.55	0.10	0.16	0.17	0.15	0.02

HEAT TREATMENT

1. Solution treated 830F (717K); Aged 5 days at Room Temp.; 240F (389K), 48 hr

830

ALUMINUM, Zn-Mg-Mn Alloys: DTD 5024 and DTD 5094

Table 5a

Temper	Form	Compo- sition, Heat Treat- ment	Test Orienta- tion	Temp (°F)	Yield Strength KSI (N2/m ²)	Typical K _{IC} KSI√in (MN m ^{-3/2})	2.5 (K _{IC} ² σ _{ys}) in (mm)	Type	Thickness in (mm)	Width in (mm)	Crack length in (mm)	Ref.
<u>DTD 5024</u>												
WP	Forging: 6 x 6 x 11 in (152 x 152 x 279 mm)	A, 1	T-S	70(294)	68(471)	19(21)	0.195 (5.0)	(a)	---	---	---	74
			S-L	70(294)	70(485)	15(16)	0.115 (2.9)	(a)	---	---	---	
WP	Forging: 6 x 6 x 4 in (152 x 152 x 102 mm)	A, 1	T-L	70(294)	63(435)	18(20)	0.204 (5.2)	(a)	---	---	---	
<u>DTD 5094</u>												
WP	Forging:	B, --	L-	70(294)	61(421)	24(26)	0.39 (9.9)	Bend	0.32 (8.0)	1.5 (38.1)	0.32 (8.1)	62
			T-	70(294)	60(414)	22(24)	0.33 (8.4)	Bend	0.32 (8.0)	1.5 (38.1)	0.35 (8.9)	
			S-	70(294)	50(400)	14(15)	0.15 (3.8)	Bend	0.32 (8.0)	1.5 (38.1)	0.32 (8.1)	

(a) Specimen in accordance with ASTM Recommendations.

COMPOSITION

	Cu	Mg	Si	Fe	Mn	Zn	Cr	Ni	Pb
A	0.5N	2.7N	0.5M	0.5M	0.5N	5.7M	-	0.1M	0.05M
B	0.5N	2.5N	-	-	0.5N	5.5M	0.2M	-	-

HEAT TREATMENT

1. 859F (733K), Water Quenched at 211F (373K); Aged 275F (408K)

ALUMINUM: 6061

Table 56

Temper	Form	Composition, Heat Treatment	Test Orientation	Yield Strength KSI (N/m ²)	Typical K _{IC} KSI√in (MPa/m ^{3/2})	2.5($\frac{K_{IC}}{\sigma_{ys}}$) ² in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
1651	Plate: 1.5 in (38.1 mm) thick	A ₁ (a)	T-L	43(296)	26(28)	0.914(23.2)	Bend	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	39
			T-L	45(310)	30(33)	1.111(28.2)	Bend	1.5 (38.1)	3.0 (76.2)	1.5 (38.1)	
	Plate: 3 in (76.2 mm) Thick	A ₁ (a)	L-T	42(290)	30(33)	1.276(32.4)	Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)	98
			T-L	41(283)	27(30)	1.084(37.5)	Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)	
1652	Forging: 9 in (229 mm) Thick	A ₁ (a)	S-L	40(276)	21(23)	0.689(17.5)	Bend	3.0 (76.2)	6.0 (152)	3.0 (76.2)	
			S-T	58(262)	23(25)	0.916(23.3)	Bend	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	111

(a) Fabrication and Heat Treatment in Accordance with Aluminum Association Standards.

COMPOSITION:

	Cu	Pb	Si	Fe	Mn	Zn	Ti	Cr
A	0.28N	1.0N	0.6N	0.7N	0.15N	0.25N	0.15N	0.2N

857

BEKYLJIM: S-200

Table 57

Form	Composition, Heat Treat- men	Test Orienta- tion	ϕ_F °F (°K)	Yield Strength ksi (N/mm ²)	Typical K_{IC} $\left(\frac{ksi\sqrt{in}}{MN/m^{3/2}} \right)$	$2\sigma \left(\frac{K_{IC}}{\phi_{ys}} \right)^2$ in (mm)	Specimen				Ref
							Type	Thickness in (mm)	Width in (mm)	Crack Length in (mm)	
Hot Pressed: 30 in (762 mm) Dia x 32 in (813 mm) long	A,-	---	70(294)	37(255)	10(11)	0.183(4.6)	Bend	0.5 (12.7)	1.0 (25.4)	0.25 (6.4)	86
Forged: 16 in (406 mm) Dia x 1 in (25.4 mm) Thick	B,-	---	70(294)	61(421)	11(12.1)	0.81 (2.1)	Bend	0.5 (12.7)	1.0 (25.4)	0.25 (6.4)	
Hot Pressed: 11 x 12 x 13 in (279 x 305 x 330 mm)	C,-	L-T	-320(78)	42(289)	7.6(8.3)	0.08 (2.1)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	124
		T-L	-320(78)	41(283)	8.3(9.1)	0.10 (2.6)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		L-T	-180(155)	40(276)	8.0(8.7)	0.10 (2.5)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		L-T	-50(228)	38(262)	3.5(9.3)	0.13 (3.2)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		L-T	75(297)	36(248)	9.5(10.4)	0.21 (5.3)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		T-L	75(297)	35(241)	11.2(12.3)	0.31 (7.8)	CT	1.0 (25.4)	2.0 (50.8)	1.0 (25.4)	
		L-T	300(422)	20(138)	9.8(10.7)	0.6 (15.2)	CT	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	
		L-T	500(533)	---	14.6(16.0)	---	CT	2.0 (50.8)	4.0 (101.6)	2.0 (50.8)	

COMPOSITION

	BcG	Fe	C	Al	Mg	Si	Be
A	16,500	1180	1000	700	40	300	Ba1(ppm)
B	17,190	1280	1300	400	110	260	Ba1(ppm)
C	1.1	0.16	0.14	0.07	0.02	0.03	98.5